The Journal of Bone and Joint Surgery

The Official Publication of
The American Orthopaedic Association
The British Orthopaedic Association
The American Academy of Orthopaedic Surgeons
The Australian Orthopaedic Association
The Canadian Orthopaedic Association
American Society for Surgery of the Hand
New Zealand Orthopaedic Association
South African Orthopaedic Association

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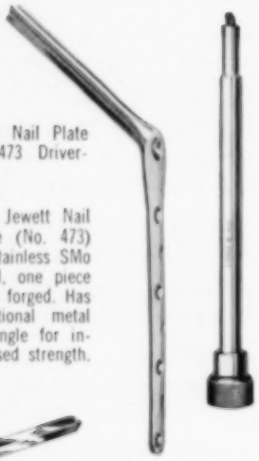

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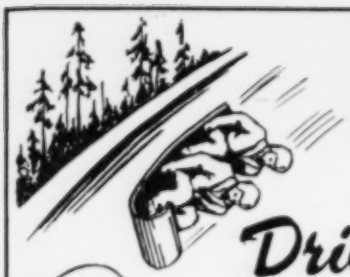

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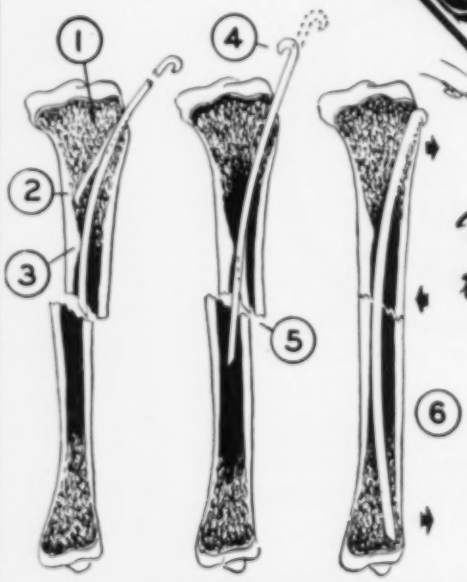

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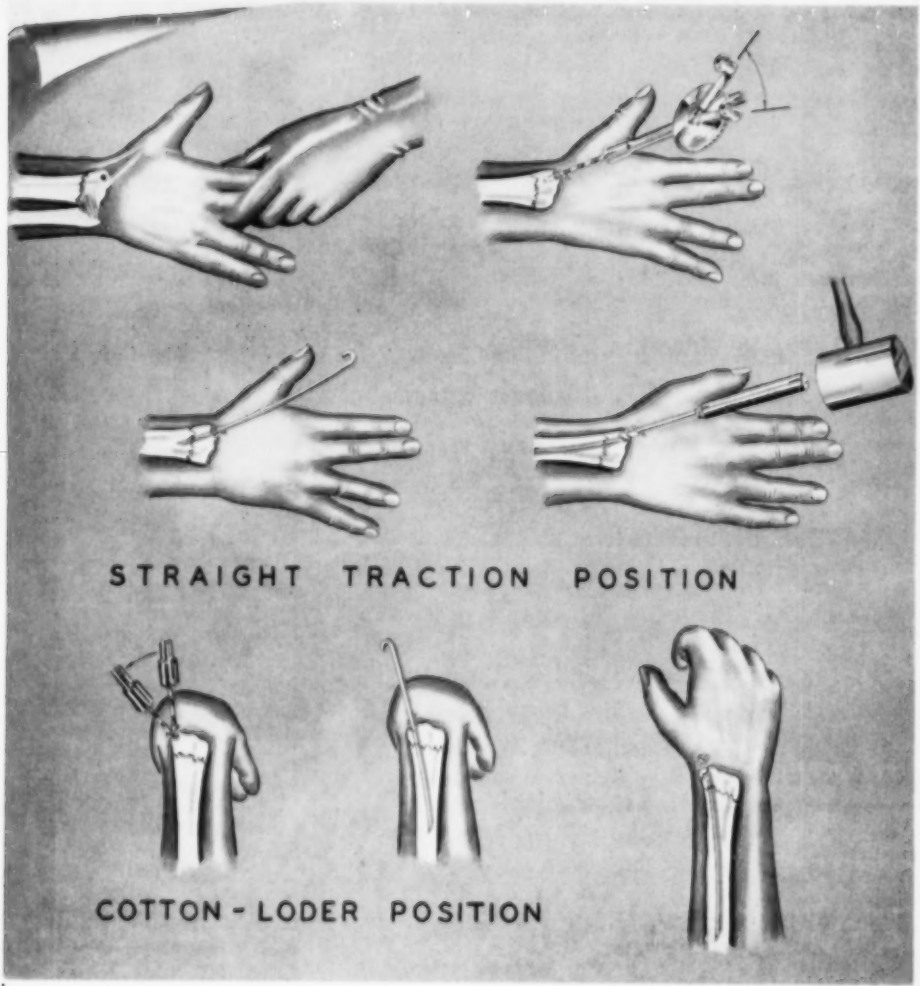

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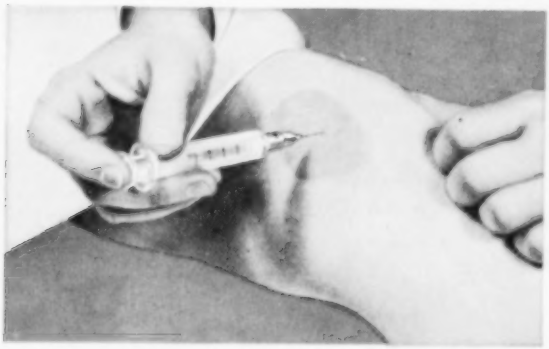

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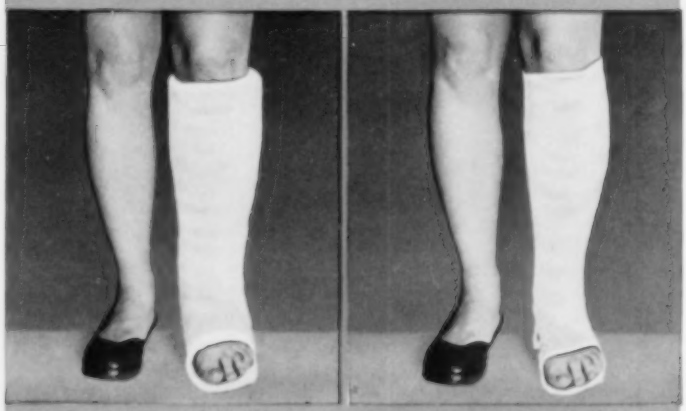

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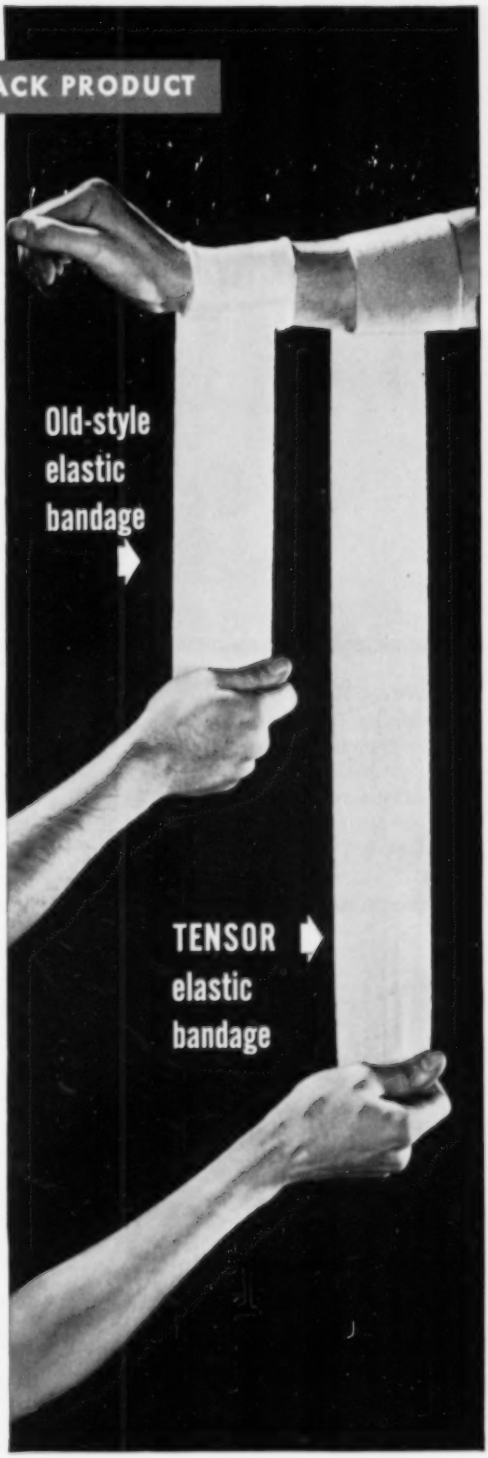

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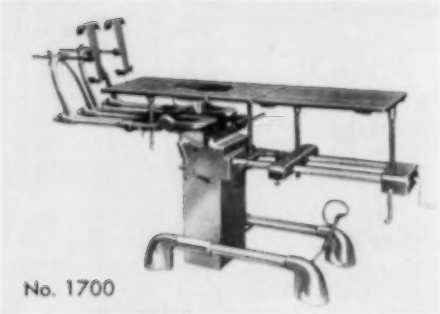

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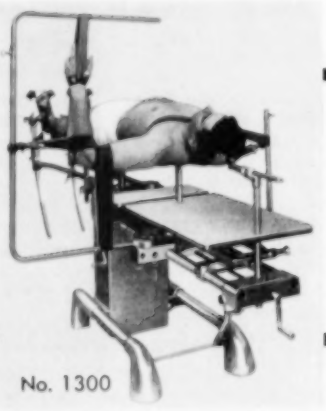

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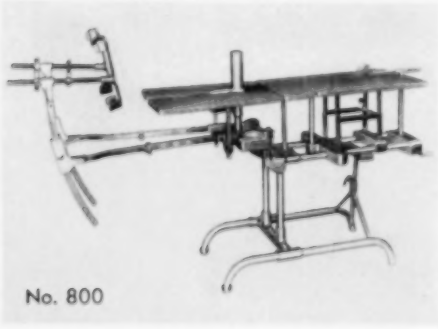

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A. Typical problem situation. Here conventional socket reaming would be very difficult and poorly controlled.

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B

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This prosthesis closely approximates the anatomical aspects of the upper femur. A substantial collar and intramedullary stem transmit the main stresses to the femoral neck and shaft. The trochanteric portion is made thin and wide to prevent rotation. It is available in four head diameters. A special Rasp is used to prepare the cavity.

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A strong and stable appliance with a threaded intramedullary shank to provide wide distribution of weight bearing stresses. The appliance is screwed into place by rotating it back and forth so the self-tapping threads cut their way to a firm seating position. A thread-cutting tap is available to prepare the bone. The greater trochanter is re-positioned over the hook and secured with a bone screw. Two head sizes.

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A popular strong one-piece appliance. The recessed underpart of the head seats firmly over the pre-shaped stump of the femoral neck. This takes the main weight-bearing strain. The stem penetrates the lateral cortex of the femur, provides stability and prevents rotation. Available in two head diameters and seven nail lengths in each.

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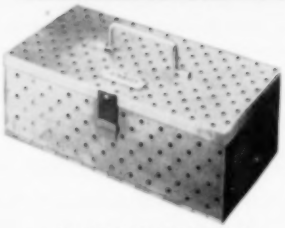

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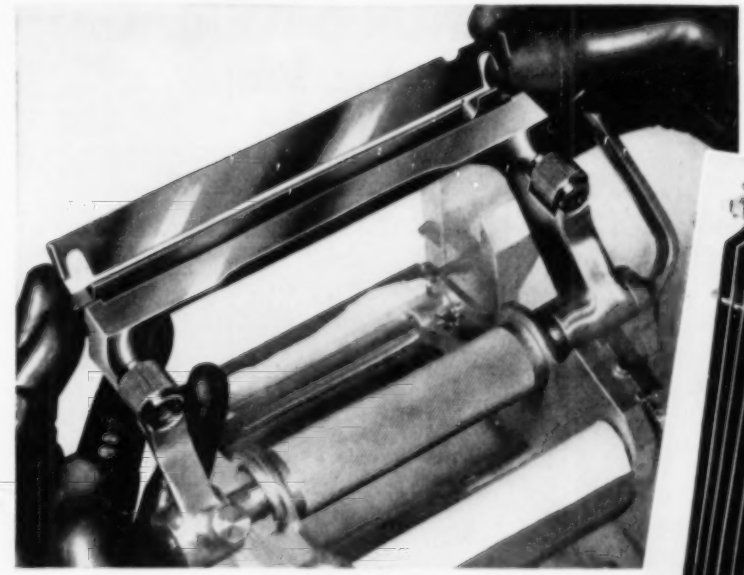

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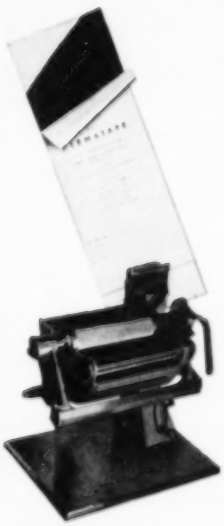

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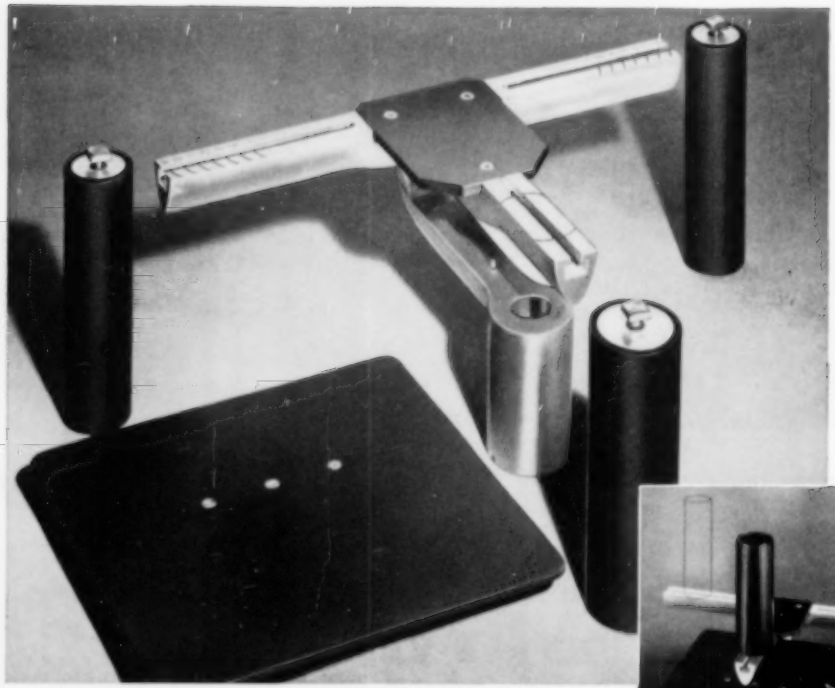

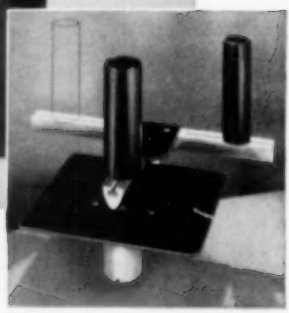

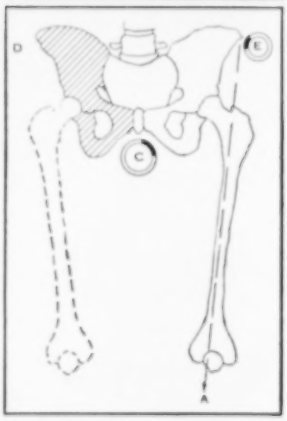

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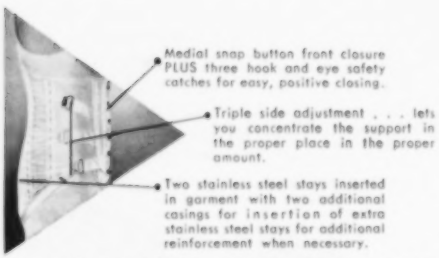
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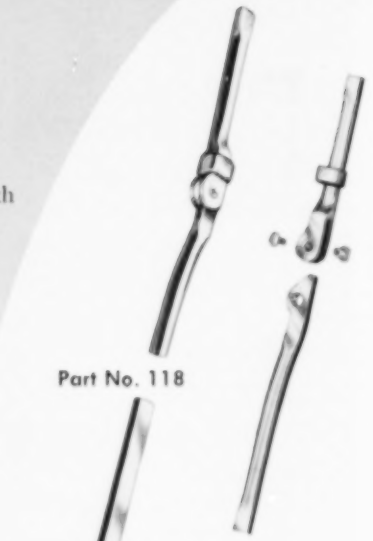

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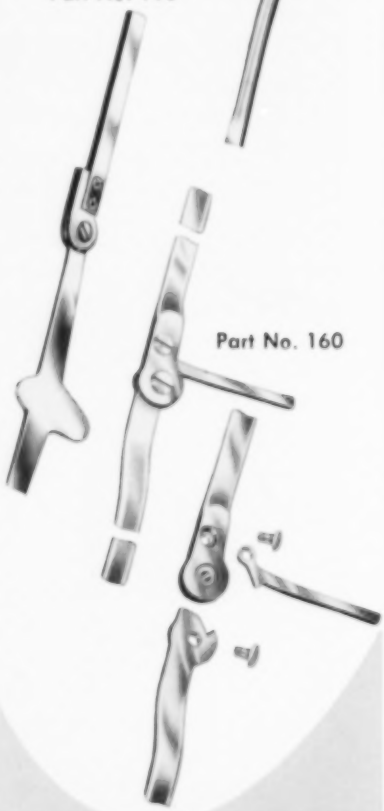

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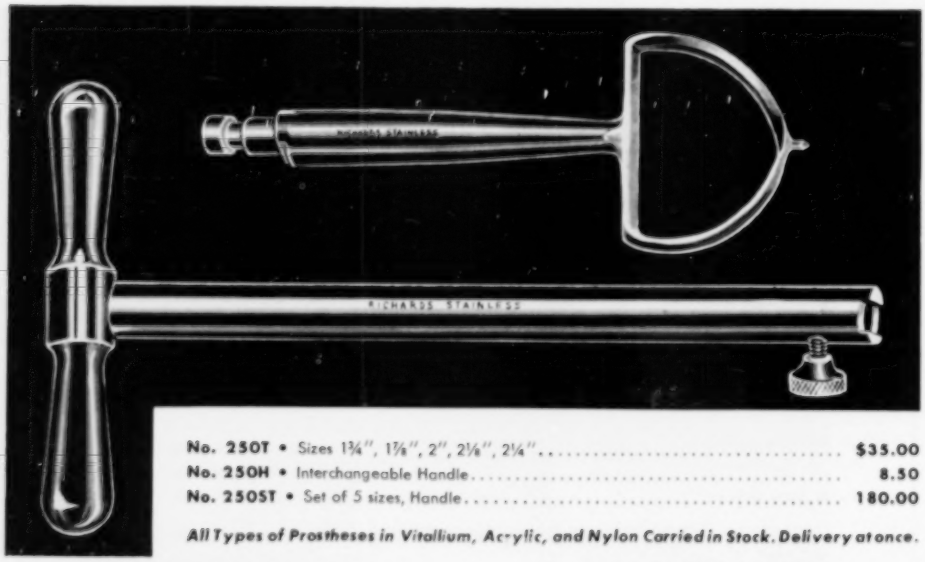

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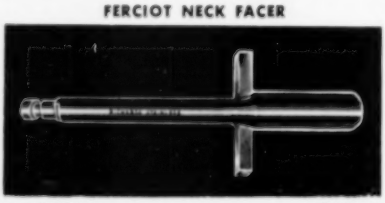

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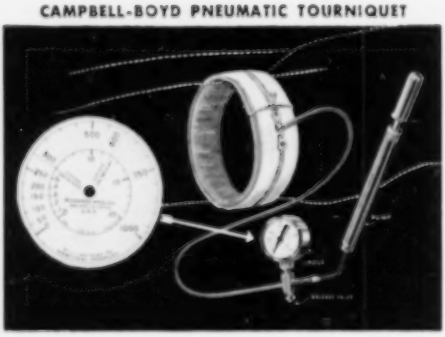

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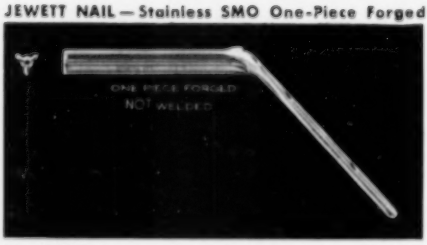

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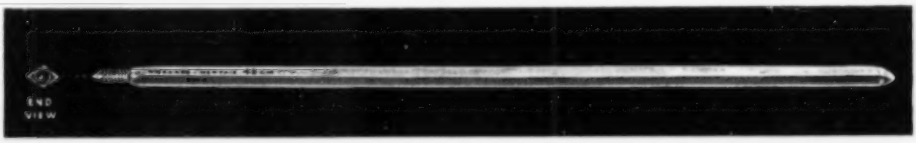

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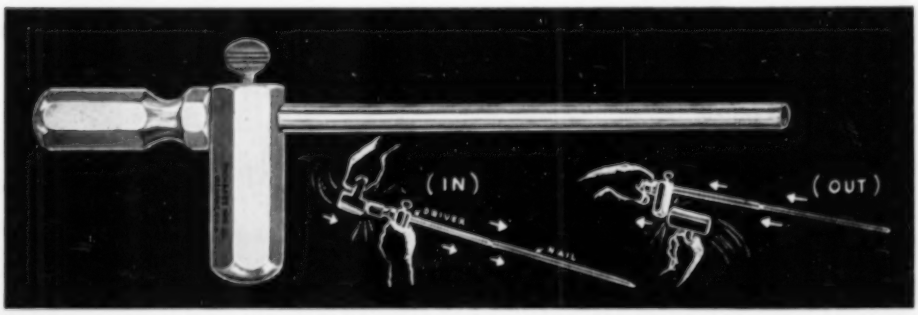

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Fractures of { TIBIA, HUMERUS, RADIUS, ULNA, PHALANGES, FEMUR }

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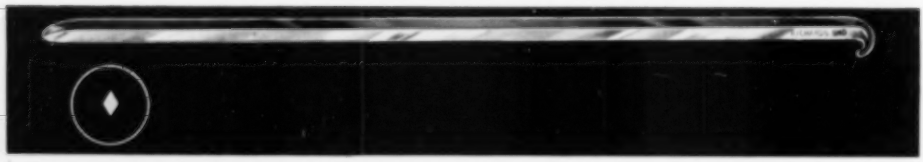

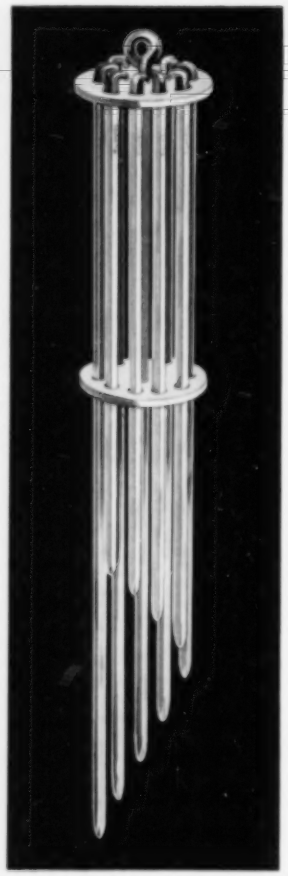

TIBIA — **Lower Third of Femur** — Complete Set $54.00
SET #1, No. 204
Each set consists of 9 Lengths
8", 8¾", 9½", 10¼", 11", 11¾", 12½", 13¼", 14"
Diameters: 4mm x 6mm — Each Pin $ 6.00

HUMERUS (Same as set #1 except 2 diameters) — Complete Set $54.00
SET #2, No. 205
Each set consists of 9 Lengths
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Diameters: 4mm x 6mm, 3mm x 5mm — Each Pin $ 6.00

RADIUS & ULNA — **(Neck of Humerus, condyles of Tibia, Humerus and Femur)** — Complete Set $52.00
SET #3, No. 206
Each set consists of 13 Lengths
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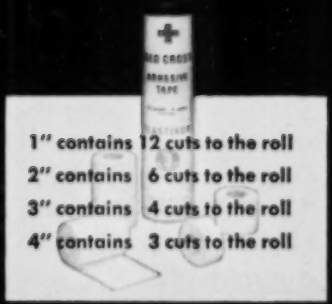

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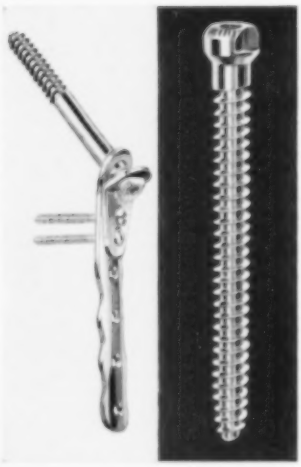

Lorenzo SMO Femoral Head

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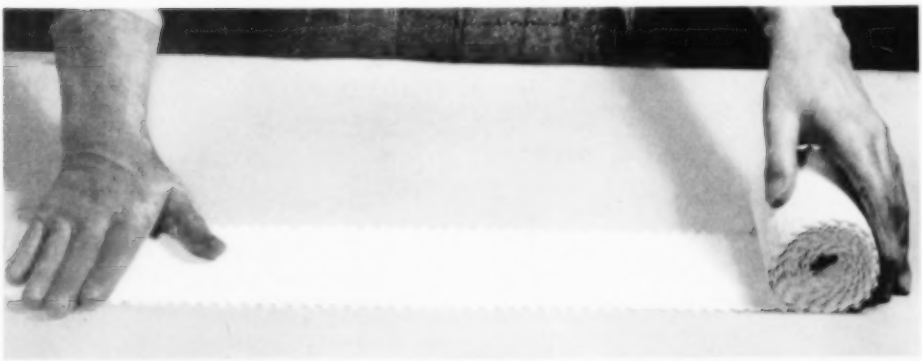

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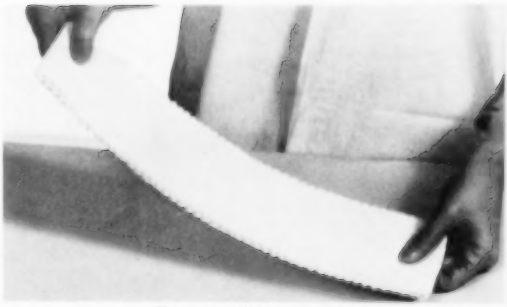

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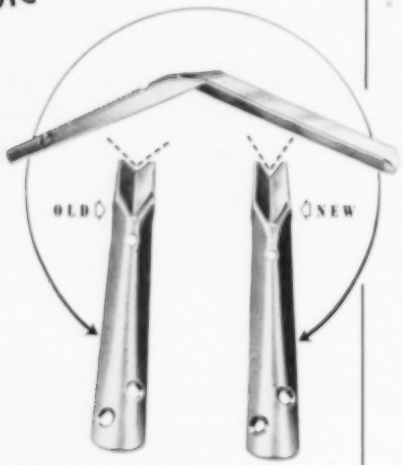

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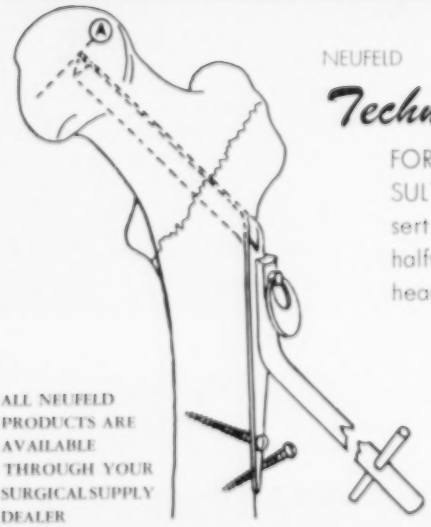

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The Hydrocollator Steam Pack is a fabric envelope containing a special heat retaining gel filler. When immersed and heated in water it becomes an efficient hot moist compress. It requires no wringing. There is no dripping. Simply wrap it in a turkish towel and apply to the area to be treated. Each application will give EFFECTIVE MOIST HEAT FOR AT LEAST 30 MINUTES. These packs can be used over and over.

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- **Relief of spasm and pain.**
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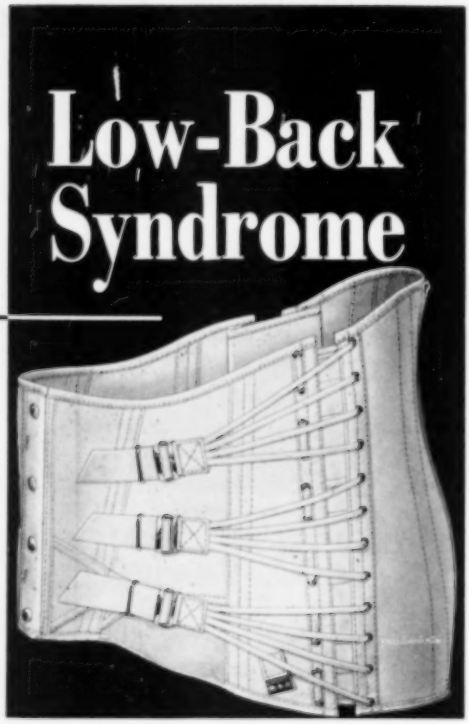

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For descriptions and illustrations of the complete TRUFORM line write for the TRUFORM Red Book, the profusely illustrated catalog which will serve as a valuable reference.

TRUFORM *anatomical supports*

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This new, streamlined Bone Pin Cutter adequately serves the needs of modern bone fixation—cuts all standard pins, nails or wire with unusual ease, safety and efficiency.

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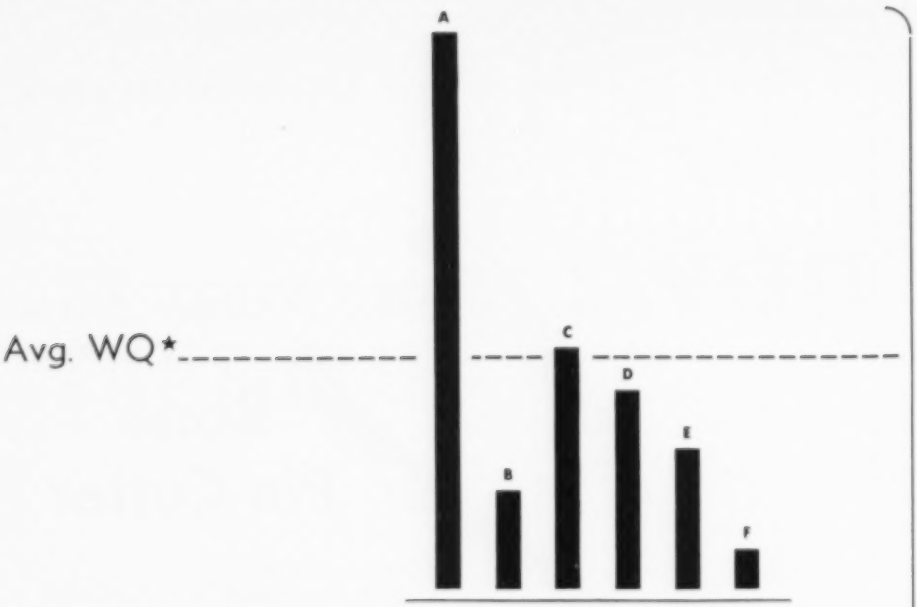

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RIGHT LEFT

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Infants' White Elk	Sizes 4½ to 8, B & EE Sizes 2½ to 8, D
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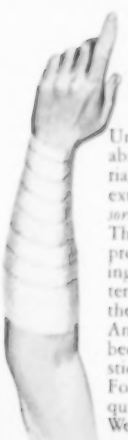

Curity WEBRIL® is the new absorbent cast padding that maintains normal skin condition

Unlike the conventional non-absorbent cast padding materials, *Curity* Webril bandages are extremely absorbent. *They absorb perspiration and skin exudate.* Thus, a Webril bandage not only protects against chafing by keeping the skin dry, it promotes better skin condition throughout the period of immobilization. And—Webril is easy to apply because it is conformable and sticks to itself—needs no taping. For patient comfort and for quick easy application, use *Curity* Webril bandages.

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1906–1907: Vol. IV, Nos. 1, 2, 3, and 4; July, October 1906; January, April 1907.
1907–1908: Vol. V, Nos. 1, 2, 3, and 4; July, October 1907; January, April 1908.
1908–1909: Vol. VI, Nos. 1, 2, 3, and 4; August, November 1908; February, May 1909.
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1912–1913: Vol. X, Nos. 1, 2, 3, and 4; August, November 1912; February, May 1913.
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1915: Vol. XIII, Nos. 1 and 2; July, October.
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THE JOURNAL OF ORTHOPAEDIC SURGERY

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THE JOURNAL OF BONE AND JOINT SURGERY

1922: Vol. IV (Old Series Vol. XX), Nos. 1, 2, and 3; January, April, and July.
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1924: Vol. VI (Old Series Vol. XXII), Nos. 1, 2, 3, and 4; January, April, July, and October.
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1928: Vol. X (Old Series Vol. XXVI), Nos. 1, 2, and 3; January, April, and July.
1929: Vol. XI (Old Series Vol. XXVII), Nos. 1, 2, and 4; January, April, and October.
1930: Vol. XII (Old Series Vol. XXVIII), Nos. 1 and 2; January and April.
1931: Vol. XIII (Old Series Vol. XXIX), No. 1; January.
1932: Vol. XIV (Old Series Vol. XXX), No. 4; October.
1933: Vol. XV (Old Series Vol. XXXI), No. 1; January.
1934: Vol. XVI (Old Series Vol. XXXII), No. 4; October.
1935: Vol. XVII (Old Series Vol. XXXIII), Nos. 1, 2, 3, and 4; January, April, July, and October.
1937: Vol. XIX (Old Series Vol. XXXV), Nos. 1, 3, and 4; January, July, and October.
1938: Vol. XX (Old Series Vol. XXXVI), Nos. 1, 2, 3, and 4; January, April, July, and October.
1939: Vol. XXI (Old Series Vol. XXXVII), Nos. 1, 2, 3, and 4; January, April, July, and October.
1940: Vol. XXII (Old Series Vol. XXXVIII), No. 1; January.
1941: Vol. XXIII (Old Series Vol. XXXIX), No. 1; January.
1944: Vol. XXVI (Old Series Vol. XLII), Nos. 1, 2, 3, and 4; January, April, July, and October.
1945: Vol. XXVII (Old Series Vol. XLIII), No. 2; April.
1947: Vol. XXIX (Old Series Vol. XLV), Nos. 1, 2, and 3; January, April, and July.
1948: Vol. XXX-A, No. 1; January.

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In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*

The Journal of
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American Volume

THE NEED FOR BASIC INVESTIGATION IN ORTHOPAEDIC SURGERY *

BY FRANCIS M. MCKEEVER, M.D., LOS ANGELES, CALIFORNIA

It is impossible for anyone closely associated with the activities of this great organization not to appreciate the profound influence which this Academy can and does exert on the specialty of orthopaedic surgery. The future of orthopaedic surgery is in the hands of this society, not only in the United States, but also probably all over the North American Continent. This is a grave responsibility, not to be taken casually. Because of this responsibility I have chosen not to enumerate to you the great accomplishment of our special field, nor to recall to you the excellent service which orthopaedic surgeons have given through the years to a world at peace and a world at war. You are all familiar with these accomplishments, and they require no retelling to this distinguished body. I do wish at this time to speak with you of one of the problems with which we must deal — specifically, of an unhealthy trend which is present in orthopaedic surgery today, and one that must be altered if our specialty is to maintain its deserved stature.

Orthopaedic surgery today is lacking in basic research, and too little animal experimentation is being done. The only gain in knowledge in the field of surgery is through observation, experimentation, and inductive and deductive reasoning. No sound progress is to be expected from the Aristotelian principles of inspiration, intuition, and dogmatism. In the broad field of surgery during the past twenty-five years there has been tremendous progress, and this progress has been due to fundamental investigation in physiology and biochemistry. Many conditions which fifteen years ago were treated on a purely empirical basis are now approached by sound scientific methods because through basic investigation they are more clearly understood. Although the orthopaedic surgeon during the past quarter century has been quick to apply the results of all basic investigation and to incorporate these results in his armamentarium for the clinical management of patients, he has not himself, I believe, contributed enough of the blood, sweat, and tears which go into the advancement of general surgical knowledge as it applies both to the broad field of surgery and to his own specialty.

To make this point more concrete, I might cite some of the advances of the past quarter century in the general field of surgery. The management of shock and the problem of fluid replacement have moved out of the empirical stage. These are both problems with which orthopaedic surgeons are associated daily. A perusal of the basic research in these subjects does not reveal the names of many people trained in orthopaedic surgery. Again, in the conquest of the field of infection none of the basic work in chemotherapy and antibiotic therapy can be claimed for our specialty. True, there are many good reports of clinical trials of these drugs in orthopaedic conditions, but these came only after the trying spade work of determining their method of production and administration and toxicity had been completed. One may say, "Well, what of it; what do you expect? These are problems for the physiologist, the bacteriologist, and the pharmacologist, and are entirely outside our field." True, these are problems which ultimately these individuals assist in

* Presidential Address presented at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 27, 1953.

solving, but only under the inspiration and the stimulus of a person who is treating patients.

Knowledge of the sources of basic progress which has brought about a sounder approach to the management of our own special problems is also disturbing. Many pathological states which we have been treating for years and which, because of our specialized training, we maintain it is our prerogative to treat, we now handle better only because of contributions from outside our specialty.

A striking example of this is osteoporosis of the spine. Orthopaedic surgeons have been seeing and treating this malady for years, but about all that we have done about it has been to give a good clinical and roentgen description of the condition and then apply a back brace. Progress in this condition was not made until intensive, trying, and time-consuming metabolic studies were carried out on patients affected with this disabling condition; and this work was done under the guidance of internists, who probably had seen very few patients with spinal osteoporosis. But they, after observing a few patients, had the curiosity to seek an answer in the laboratory. They did not just dogmatically apply a mechanical aid to alleviate pain and let it go at that.

The field of peripheral vascular disease is another region in which the orthopaedic surgeon has failed to meet the challenge. For years we have been amputating gangrenous extremities and to a degree developing prostheses. For some unknown reason the physiology of this problem has not interested our specialty. Practically none of the basic work on the sympathetic nervous system and the new direct approach to arteriosclerosis has had its origin in the thinking of orthopaedic surgeons.

Rheumatoid arthritis as a systemic disease has failed to interest very many individuals reared in our training program. For decades the orthopaedic surgeon had most of the responsibility for the rheumatic patient. It is true that we have done a good job along mechanical lines in the prevention and correction of deformities; but the real challenge of the problem failed to arouse the interest or to stimulate the imagination of the orthopaedic surgeon, and a whole new specialty of rheumatology has evolved as a result of our attitudes of empiricism and dogmatism. It is possible to proceed much further along this road of missed opportunities. However, I will not discuss the various facets of the problems of poliomyelitis, bone metabolism, growth, and repair, concerning which it might logically be expected that the physician trained in orthopaedic surgery would have a basic and tenacious curiosity.

In order to check my own thinking on this matter, I have surveyed the orthopaedic literature as published by *The Journal of Bone and Joint Surgery* for the five years 1947 through 1951. This span of years was selected because it was felt that it represents the present trend of thinking and also represents a period of relief from the tremendous load of pressing practical problems forced on all surgeons, but more onerously on the orthopaedic surgeon, by World War II. During this five-year period *The Journal of Bone and Joint Surgery*, which certainly has access to the achievements of orthopaedic surgeons, published 753 papers. Only twenty-six of these papers, or 3.45 per cent., present material based upon animal experimentation. Thirteen of these papers were the product of others, not orthopaedic surgeons or departments of orthopaedic surgery. They were contributed by anatomists, pathologists, physiologists, and in one instance by a department of physical medicine. This means that, in the five-year period since World War II, exactly thirteen articles with any direct background of animal experimentation out of 753 articles, or 1.73 per cent., published in the outstanding orthopaedic periodical were contributed by orthopaedic surgeons. In carrying this analysis a step further, it was found that these thirteen articles containing animal experimentation were contributed by only eight individuals or departments of orthopaedic surgery.

The Journal, during this same period, has published many excellent end-result studies, anatomical treatises, and much fine work in the field of pathology. These types of medical

papers are all very necessary and further our knowledge, but unless anatomy and pathology are coupled with physiology and physiological chemistry, they become static and are only records of roads already traveled; few new avenues are opened, and little is added to the general body of surgical knowledge. The thousands of pages of orthopaedic literature disseminated during this five-year period contain many procedures which are probably widely employed on many patients, such as the section of peripheral nerves for the relief of pain and the implantation of many and varied materials in sundry shapes and forms to substitute for parts of the human body. Permanent irreversible changes are the result of many of the procedures advocated, but for most of them there is little precedent in animal experimentation.

The reasons for this trend are many. Some of them stem naturally from the unrest and uncertainty of the times. About these causes we can do very little except to remember that many of the epochal scientific discoveries were the products of the most troubled times. Yet there are other factors that deal directly with situations which we sponsor and over which we have control. Many of the basic problems confronting us in orthopaedic surgery are difficult and obscure. The answer to them is not quickly or easily reached; consequently we employ an obvious substitute, while the basic problem lies unexplored. An example of this is aseptic necrosis of bone after any fracture. The real quest is to find a way of determining at the time of the injury which fracture will tend to eventuate in aseptic necrosis, and then to determine how to prevent this occurrence. The same applies to the great field of arthroplasty. The solution is probably somewhere in the realm of physiology or biochemistry, and not in the realm of metallurgy or the organic chemistry of acrylics. I think there is no one who feels that the real solution of these problems will result from shaping, molding, channeling, or bending a piece of stainless steel or even from toying with a crystal ball on the end of a rod of stainless steel. These are only stopgaps to relieve patients until the true answer is found. We must not lean heavily on these palliatives or be content with them. The answers to these and to many other difficult and untouched problems will undoubtedly emerge from the synthesis of the investigative skill of many basic scientists; but it takes time and contemplation to organize and put them together.

Another and perhaps the greatest drawback to basic and fundamental research in orthopaedic surgery is the paucity of adequately remunerated chairs of orthopaedic surgery in our medical schools. The greater part of the orthopaedic teaching in our medical schools is done by clinical professors and their voluntary assistants. These are a group of men who, at great sacrifice to themselves, do a splendid and irreplaceable job of training men in practical orthopaedic surgery. Their services can never be replaced, and their contribution is great. However, by virtue of the demands on their time, the pressure of their work, and the temperament which goes along with this load that they carry, it cannot be expected that they will do more than train good residents who will make competent orthopaedic clinicians. They do not have the peace of mind, the time for contemplation and quiet reasoning which are necessary to the stimulation and production of good research.

Another factor which bears noticeably on the productiveness of investigation is the type of training given to neophytes in the orthopaedic field. Orthopaedic training has been gradually standardized, and, since the establishment of The American Board of Orthopaedic Surgery in 1934, the general level of orthopaedic residencies has been raised to a very high plane. Personal experience with the Board gives me first-hand knowledge that this has been done only with the idea of improving the product delivered to the public and preventing the exploitation of the trainee. The American Board of Orthopaedic Surgery has had a profound influence on teaching in our specialty for almost twenty years. I think no one questions the benefits of its influence, but I believe there is now cause to wonder whether its present requirements may not, to a degree, have placed a strait jacket on original thinking, and whether these requirements may not in time lead to a highly efficient mediocrity in our specialty. In any educational field, over-standardization

can result in a supply of expert apprentices, rather than of individuals with foresight, curiosity, and imagination.

However, one is not justified in offering criticism alone, without projecting some solution to correct the faults pointed out. My reason for speaking of what appears to me to be an unhealthy trend in orthopaedic surgery today is that I believe this Academy has the power to modify this trend. Furthermore, I believe this society is the only organization possessing such authority and that, if it does not assume the task, no other will. No medical society thrives indefinitely on the repeated presentation of a scientific program and social concourse. On this sort of procedure it rapidly reaches a stage of excellence from which it levels off and deteriorates. To remain really great, a medical organization must have ever-expanding and worthy objectives, even though of long range and difficult attainment. To assure its own future development and to fulfill its stated objective of advancing orthopaedic surgery in all its phases, I feel that The American Academy of Orthopaedic Surgeons should at present concentrate its efforts on correcting the most glaring defect in our development. First, it should search for the causes of the lack of basic investigation in our specialty in order that they may be corrected; second, it should exert every effort to stimulate and foster this basic investigation.

A suggestion for a good starting point would be that a group of individuals with some demonstrated skill and interest in academic work be appointed to study the entire Board problem and its possible relationship to basic research in orthopaedic surgery. The Board's requirements for admission to examination as well as its method and type of examination should be studied. Such a committee would be more sound if it included some educators who were not orthopaedic surgeons. Any constructive ideas, based on careful investigation and weighed judgment, would I am sure be welcomed collectively and individually by all members of the Board. Through the years there has been considerable criticism of the activities of the Board. Not much of this criticism has been arrived at by considered judgment of its problems; some has been without actual knowledge of its methods; and little or none has been constructive in nature.

Basic research in orthopaedic surgery can most easily be developed and fostered in teaching centers. This can be accomplished by the establishment of chairs of orthopaedic surgery in our universities with sufficient financial remuneration so that they will attract men with properly developed minds and leave these minds free to attack our obscure problems without the necessity of being interrupted by a private practice to keep body and mind together. I am not implying that the clinical professor and part-time teaching staffs should be discontinued. They should still continue to carry the major load of teaching. If they worked in conjunction with a well organized department which was probing some of our unsolved problems along truly scientific paths, the reward of this generous group of men would be greater and their frustration less.

The power of this Academy is easily demonstrated. A voluntary subscription of twenty-five dollars per year by each member would establish a university post in orthopaedic surgery which would attract a very excellent mind and give it a chance to function. I am not soliciting funds and I do not think that this is the correct approach to this problem. It would create only one such opportunity, and this is not enough. I believe you have already taken the first step along a path which can accomplish this objective and many more. As a result of the Presidential Address of our esteemed Past President, Dr. Guy Caldwell, the Committee for the Advancement of Orthopaedic Surgery was implemented. This Committee, at some expense, has conducted a pilot survey of our problems. Although the cost in dollars may appear high, the information obtained from this survey is beyond price. From this survey has come an idea which at first sight may appear to be a daring departure from the conventional conduct of a medical society. This idea is that The American Academy of Orthopaedic Surgeons create a lay affiliate, composed of representa-

(*Continued on page 354*)

A NEW METHOD FOR DETERMINATION OF TORSION OF THE FEMUR *†

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Since 1868 when Julius Wolff, who is best known by the law for bone growth which bears his name, made a careful study of the structural architecture of the neck of the femur and recognized a normal torsion of the femur, there has been a continuous and, recently, an increasing interest in this subject. Many exhaustive studies have been made on dried femora, and a few fluoroscopic studies have been made on living subjects; but during this period no accurate method was reported for the determination and permanent recording of femoral torsion in the living subject. In May 1951, the senior author, then a resident at the Alfred I. duPont Institute, realizing the importance of knowing the amount of torsion of the femur for a rotation osteotomy in a girl, six years of age, who had had an open reduction of a congenital dislocation of the hip, devised a simple roentgenographic technique for measuring and recording femoral torsion on a single roentgenogram. What happened in this case, in which a typical supracondylar rotation osteotomy had been performed without an accurate determination of femoral torsion prior to surgery, is recorded in Figures 1-A, 1-B, 1-C, and 1-D, and undoubtedly represents what is happening today in many clinics in the treatment of congenital dislocation of the hip.

This first report on this new method of determining femoral torsion by roentgenograms is concerned with (1) terminology, (2) literature, (3) description of the method, positioning of the apparatus, and interpretation of the roentgenograms, (4) description of skeletal studies to determine the accuracy of the method and the sources of error, and (5) the normal and abnormal findings in the roentgenograms of the hips of 499 children and 103 adults.

TERMINOLOGY

Torsion is defined as the deformation of a body, such as a rod, by twisting; one end is held fast while the other end is turned around on its length as an axis. In the femur, which is comparable to a rod, the lower or condylar portion is the end which is held fast and remains fixed, while the upper portion is the end which is turned around on its length as an axis. The amount of twisting or torsion is determined by measuring the angle formed by the plane of the central axis of the neck with the plane of the transcondylar or fixed lower-end axis. This lower axis is in the frontal or coronal plane of the femur. If the plane of the femoral-neck axis points forward or anterior to the frontal plane, the angle of torsion is designated as a "plus" angle and is referred to as *anteversion*, *antetorsion*, or *anterior twist*. If the plane of the femoral-neck axis points backward or posterior to the frontal plane, the angle is designated as a "minus" angle and is referred to as *retroversion*, *retrotorsion*, or *posterior twist* (Fig. 2). Femoral torsion is referred to by some authors as the "angle of declination". This latter term may be misleading as to what the angle really is, and is often confused with the angle of inclination which is that angle formed by the femoral-neck axis with the femoral-shaft axis (the so-called shaft-neck angle) as seen on an anteroposterior roentgenogram. Most observers believe that the torsion of the femur, causing an anteversion or retroversion of the axis of the neck, occurs in the shaft and does not occur in the neck.

* The original portion of this work was presented as an exhibit at the Annual Meeting of The American Academy of Orthopaedic Surgeons in Chicago, Illinois, January 1952, and was awarded First Place in Class I, Research for Scientific Value.

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LITERATURE

The literature on torsion of the femur has been divided into three sections: (1) the methods for the determination of torsion; (2) investigations on dried femora; and (3) the relationship of torsion of the femur to congenital dislocation of the hip.

1. *Methods of Determination of Torsion*

For the determination of the degree of torsion in the dried femur, most investigators have placed the condyles on a flat surface, such as a table which represents the plane of

FIG. 1-A

Anteroposterior roentgenogram of the pelvis of a girl aged six years with congenital dislocation of the left hip. Four unsuccessful reductions, three closed and one open, had been performed on the child from eighteen months to five years of age.

FIG. 1-B

Anteroposterior roentgenogram of the same patient, six months after open reduction, following which a plaster spica had been applied with the left lower extremity in marked abduction and internal rotation. One week following the open reduction, a supracondylar rotation osteotomy had been performed. The left lower extremity below the site of the osteotomy was derotated from the internally rotated position to a position in which the patella and foot pointed forward.

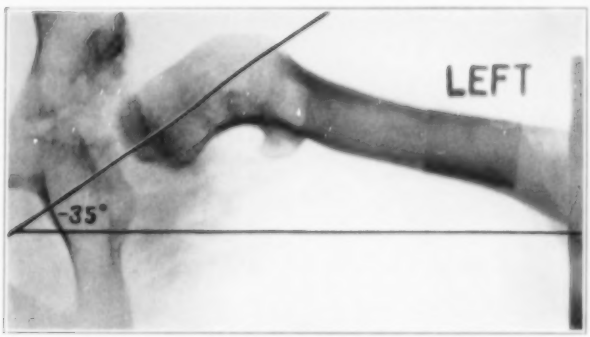


Fig. 1-C: Lateral roentgenogram of left hip in the authors' position six months following open reduction and supracondylar rotation osteotomy. There was a marked retroversion of −35 degrees. The amount of anteversion in this hip before the rotation osteotomy had not been determined. This illustrates the importance of determining the amount of anteversion before performing a rotation osteotomy, for certainly a hip with a retroversion of this degree is not to be desired.

Fig. 1-C

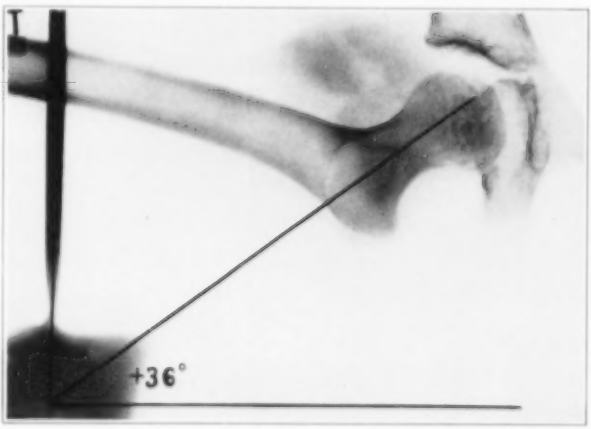


Fig. 1-D: Lateral roentgenogram of the non-dislocated right hip in the authors' position showing an anteversion of +36 degrees.

Fig. 1-D

the transcondylar axis, and with a goniometer or protractor have measured the angle which the axis of the neck forms with this surface (Fig. 3). In this method, with a plus angle, the femur rests on the condyles and posterior aspect of the greater trochanter, and with a minus angle, the femur rests on the condyles and the head. In the latter instance, two small flat blocks are often used, one placed beneath the condyles and the other beneath the greater trochanter, which allow the head to lie beneath the flat supporting surface. In the study of Kingsley and Olmsted, the central axis of the neck was determined accurately with a height gauge, and the angle was measured with a specially constructed protractor with a long metal arm.

In 1930, Fairbank wrote, "The accurate estimation of the angle of antetorsion in the living subject is a matter of considerable difficulty". This statement has been repeatedly confirmed in the reports of the investigators. Up until 1926, when Stewart and Karschner reported a fluoroscopic method of determining femoral torsion on the living subject, all determinations were either an estimate of torsion from a clinical examination or an estimate from two roentgenograms, one taken with the hip in a neutral position and the other taken with the hip in internal or external rotation. Soutter and Bradford, in 1903, first described a roentgenographic technique as follows:

> "To determine the degree of rotation, it is necessary to take the skiagram with the foot in such a position that it points directly forward and from the more or less prominence of the head, an estimate of the degree of rotation can be made. If the skiagram of the limb is taken also with the foot strongly everted, the length of the neck can be estimated in the difference shown in the two skiagrams."

In 1909, Turner mentioned using the method of Soutter and Bradford in determining torsion of the femur in cases of congenital dislocation of the hip. In 1926, Farrell, von Lackum, and Smith referred to estimating anteversion in 310 cases of congenital dislocation of the hip from two roentgenograms of the hip, one taken with the knee and leg pointing straight forward, and the other with the lower extremity rotated inwardly as far as possible. In 1926, Krida, Colonna, and Carr spoke of recognizing anteversion by roent-

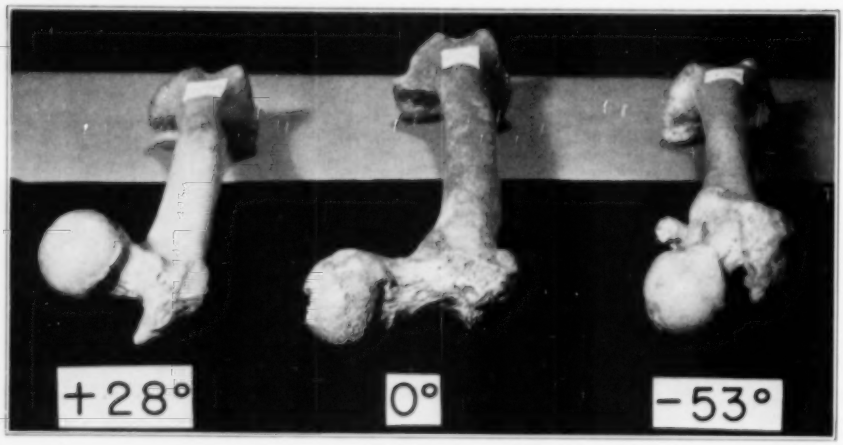


FIG. 2

Fig. 2: Specimens of three dried femora demonstrating plus torsion or anteversion, no torsion, and minus torsion or retroversion, respectively. The anteversion specimen (+28 degrees) is from an adult whose skeleton had evidences of rickets; the femur without torsion (0 degrees) is from an apparently normal skeleton used in teaching; and the specimen with retroversion (−53 degrees) is from an adult who had suffered an intertrochanteric fracture.

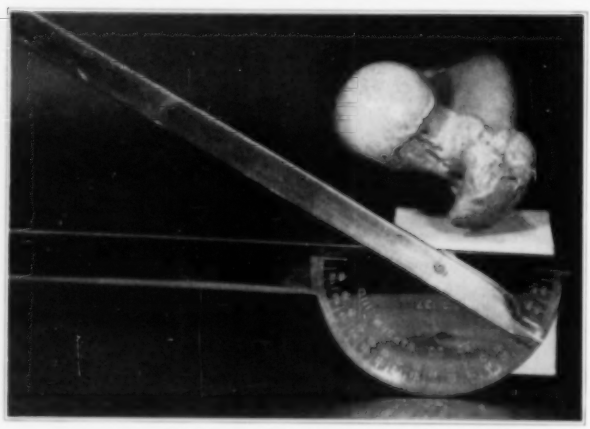


FIG. 3

Fig. 3: Method similar to that of Kingsley and Olmsted of determining torsion of the femur in a dried specimen. The trochanteric area of the femur is placed on the top of a block of wood with the condyles of the femur resting on a parallel flat surface. One arm of the goniometer is aligned with the top of the block of wood, which parallels the transcondylar axis, while the other arm is aligned with the central axis of the neck of the femur. The angle formed between the two arms of the goniometer is the angle of torsion, which, in this femur, is +27 degrees.

genograms, as well as clinically. Krida, in 1928, wrote of taking roentgenograms, first with the patella directed sagittally, and second with the extremity rotated inwardly; he stated that the greater the degree of discrepancy, the greater is the amount of anteversion. Krida referred to the technique as *Drehmann's method*.

In 1926, Stewart and Karschner reported a procedure to determine femoral torsion by placing the patient in the prone position on a fluoroscopic table and by flexing the patient's knee on the affected side to 90 degrees, with the tibia vertical. The leg is carried toward the unaffected side, that is, the femur is externally rotated, until the head, neck, and shaft of the femur are in a straight line. A goniometer is used at the knee with one arm of the goniometer parallel with the leg at all times. This reading is subtracted from 90 degrees, and the resulting figure represents the amount of antetorsion. Rogers, in 1931, described a similar fluoroscopic technique. He stated that, when the head-neck angle disappeared fluoroscopically, the angle between the leg and fluoroscopic table is the angle of femoral torsion. The margin of error with the Stewart and Karschner and Rogers methods is thought to be not more than 5 degrees. Rogers also wrote of taking two anteroposterior hip roentgenograms, one with the patella pointing forward and the other with the lower

extremity rotated inwardly, and stated that the length of the femoral neck in the first view, which is the apparent length, divided by the length of the neck in the second view, which is the actual length, represents the tangent of the angle of torsion. In 1934, Rogers, using this method, studied ninety-nine normal hips in children, finding approximately +49 degrees of femoral torsion at one year of age and +16 degrees at fourteen years of age.

From the time of these reports to the present, there has been no more exact method described for determining the angle of torsion of the femur in the living subject. All observers continually spoke of the inaccuracy of these methods; and Farrell, von Lackum, and Smith went so far as to state that invariably two or more surgeons will make different estimates in the same case.

2. *Investigations on the Dried Femur*

Most of the investigations on torsion of the femur have been carried out on dried specimens from museums and anatomy and pathology laboratories. These specimens have supposedly been normal femora, but there is no doubt that some may have been from skeletons with pathological conditions. A review of these studies, in order of publication, is as follows:

1. 1878. Mikulicz, in a study from the anatomy laboratory, found the variation of torsion of the femur to be from +37 to −25 degrees, with an average of +11.6 degrees.

2. 1896. Broca (according to Testut) found a variation of from +38 to +2 degrees.

3. 1903. Soutter and Bradford studied 154 femora and found the variation to be from +50 to 0 degrees, with an average of +14.3 degrees.

4. 1914. Parsons studied 300 very old femora and found a variation of from +40 to −17 degrees, with an average of +15.5 degrees. He found the torsion to be greater in women than in men.

5. 1915. Durham reported on a study of 200 normal femora. He found the variation to be from +35 to 0 degrees, with an average of +11.9 degrees. In eighteen femora the reading was 0 degrees, in eighty (40 per cent.) between +10 and +2 degrees, and in only two specimens was the reading over +30 degrees.

6. 1941. Pick, Stack, and Anson reported on the measurements of 152 cadaver femora, 5 per cent. of which were female. They found the variation to be from +41 to −18 degrees, with an average of +14 degrees.

7. 1948. Kingsley and Olmsted studied 630 individual adult femora, forty-five known pairs of adult femora, and thirty-two pairs of femora of infants and children of known age, for a total of 784 femora. Their findings in the 630 single adult femora showed that the variation was from +38 to −20 degrees, with an average of +8.021 degrees. The average for the right femora was approximately 1 degree higher than that for the left. The difference between the male and female femora was negligible. In thirty infant femora, the variation was from +64 to −10 degrees, with an average of +24.4 degrees; and in the femora of twenty-six children, aged two to fifteen years, the variation was from +38 to −4.5 degrees, with an average of +17.2 degrees. Nineteen per cent. of the femora had an anteversion greater than +15 degrees; 66 per cent. were between +15 degrees and 0 degrees; and 14.8 per cent. were between −.5 degrees and −20 degrees. They considered +15 degrees to be the upper limit of normal in the adult femora.

In 1919, Pearson and Bell, in a book entitled *Study of the Long Bones of the English Skeleton*, stated that the angle of torsion is +15.3 degrees.

The combined statistics of five of these reports, totaling 1,524 femora (Soutter and Bradford; Parsons; Durham; Pick, Stack, and Anson; and Kingsley and Olmsted) show the variation to be from +50 to −20 degrees, with an average angle of torsion of +11.2 degrees. The study of Kingsley and Olmsted is by far the largest and most exact of any study, and the correct figure may be nearer to their average of +8 degrees. In determining the central-neck axis, Kingsley and Olmsted did not use any point on the head, as 68.7 per

cent. of the heads in their study were not centered on the neck. It is most likely that the other investigators used a head-neck axis, and this fact may account for the difference in their readings and those of Kingsley and Olmsted.

3. *The Relationship of Torsion of the Femur to Congenital Dislocation of the Hip*

Nearly every publication on congenital dislocation of the hip refers to the significance of anteversion or antetorsion. Some authors, such as Galeazzi, have considered it to be the most important single factor in the development, treatment, and prognosis of the condition.

The most accurate report on the amount of torsion in the femur in congenital dislocation of the hip was made by Fairbank in 1930. He examined twenty-six museum specimens and found that the variation was from +75 to 0 degrees and the average, +30.6 degrees. In 1931, Rogers reported eight cases with an anteversion of from +40 to +85 degrees.

Werndorf, in 1912, Hibbs, in 1915, and Krida, Colonna, and Carr, in 1926, wrote that anteversion might attain +90 degrees, which opinion is concurred in by Steindler. Froelich, in 1921, in reporting on 1,000 cases of congenital dislocation of the hip stated that in only 1 per cent. is there found an extreme degree of antetorsion; this is not in agreement with most of the other reports. In 1920, Lorenz [27] stated that whenever he sought the cause of reluxations in replaced hips, he found, as a rule, a marked degree of antetorsion forced itself into the foreground as the proximate cause. In 1924, Soutter and Lovett, in a study of 227 dislocations wrote, (1) "torsion of the neck, therefore, means in prognosis that the hip is apt to be less stable after reduction" and (2) that 73.5 per cent. of the difficult cases had a moderate or greater degree of torsion. In 1926, Farrell, von Lackum, and Smith, in a study of 310 cases with 395 dislocated hips, reported 47 per cent. had an anteversion of +20 degrees or more and 24 per cent. had an anteversion of over +50 degrees. They stated, "it is one of the prime factors producing dislocation as well as causing the dislocation to recur after reduction". In 1935, Stewart mentioned that a high degree of anteversion was incompatible with retention of the head of the femur in the acetabulum.

In 1947, Leveuf wrote that anteversion was present in 68 per cent. of his cases of congenital subluxations and that it increased progressively if the luxation remained unreduced. In 1951, Massie and Howorth reported an anteversion in forty-two of fifty-two hips (80 per cent.) requiring open reduction and stated that in anterosuperior dislocations it is from +30 to +70 degrees. They stated that anteversion is a cause of resubluxation after a good reduction and that a hip with an anteversion of more than +45 degrees slips out easily unless internal rotation is maintained. They further stated that prolonged dislocation is thought to be one of the causes of anteversion.

In 1914, LeDamany wrote on the cause of anteversion: He stated (1) that up to the fourth month of pregnancy, the planes of the axis of the neck of the femur and the axis of the shaft in the embryo are parallel or that the angle of torsion is 0 degrees; (2) that by the time of birth, a torsion of the neck on the shaft has taken place which is from +30 to +50 degrees; and (3) that with weight-bearing this gradually decreases until at the end of the growth period the torsion is +12 degrees. The development of torsion *in utero* is thought to be due to the fact that during the second half of pregnancy acute flexion of the hip takes place and a force of internal rotation on the long femoral shaft is produced from pressure upon the knee by the uterine wall. Partial correction of this angle after birth is thought to be due to the extrinsic factors, such as muscle pull in the opposite direction and capsular restriction as the hip joint extends.

In 1923, Whitman stated that at birth the angle of torsion is +35 degrees which is gradually reduced to +15 to +10 degrees when the erect posture is assumed by pressure on the tense capsule, but, if the hip is dislocated, this reduction does not take place. The figures of Whitman and LeDamany are concurred in by Stewart and now are generally accepted by most investigators.

In 1943, Badgley differed with LeDamany as to cause. Following a careful study of hips in congenital dislocation with anteversion and hips in arthrogryposis multiplex congenita with inadequate musculature and no anteversion, he concluded that antéversion is due to the intrinsic muscle factors and not to the mechanical factors as described by LeDamany. Badgley further stated that as a result of anteversion, a secondary hypoplasia of the acetabulum takes place with a subsequent dislocation of the hip.

In congenital dislocation of the hip with anteversion, many authors, such as Schede, in 1897, Werndorff, in 1912, Hibbs, in 1915, Krida, Colonna and Carr, in 1926, McCarroll and Crego, in 1939, and Massie and Howorth, in 1951, advocated a rotation osteotomy either in the supracondylar or subtrochanteric area of the femur to correct the anteversion. Massie and Howorth, as well as Durham, recommended that a femur with an anteversion of more than +45 degrees should be corrected by osteotomy, while Werndorff only did a correctional osteotomy if it was +60 degrees or over. This was done either before or after reduction. Hibbs, in 1915, also advocated the osteotomy, oftentimes before reduction; however, Farrell, von Lackum, and Smith, in 1926, from Hibbs Clinic, wrote that ordinarily osteotomy should not be done until after the hip had been reduced. Others, such as Gill, Lorenz, Bradford, Soutter, and Compere and Schnute, were of the opinion that an osteotomy is not necessary for a good result and that the anteversion will usually correct itself. Lorenz, in 1905, went so far as to say that operative correction of the anteversion may lead to a posterior subluxation. Bradford wrote that, if the reduction has been complete and stable, locomotion and joint function becomes normal despite the femoral twist which tends to correct itself after reduction. Soutter and Lovett, in 1924, stated that, in their experience, cases of congenital dislocation with extreme torsion have improved markedly after two or three years of weight-bearing. Fairbank, in 1930, stated that, if the hip is reduced before the fourth year, it is very rare to have to do a rotation osteotomy in order to correct the anteversion.

All of these observations and reports emphasize and re-emphasize the importance of anteversion in the treatment and prognosis of congenital dislocation of the hip and the necessity for an accurate determination of the amount of this torsion present.

Among the many others who have discussed anteversion, retroversion, and torsion of the femur in the literature are Brandes, Bruce, Campbell, Haas, Hart, Murray, Netter, Ollerenshaw, Ponsetti, Putti, Severin, Sherman, Stern, and Wiberg.

THE METHOD

In the authors' method, the anatomical or true angle of torsion of the femur is determined as follows:

1. A postero-anterior roentgenogram of the pelvis and hips is taken, and on this film is measured the apparent angle of inclination.

2. A lateral roentgenogram of the hip is taken with the lower extremity precisely positioned in a simple apparatus which has an attached radiopaque reference bar; on this film is measured the apparent angle of torsion.

3. The true angle of torsion is determined from the apparent angles of measured torsion and measured inclination with the use of a graph prepared from a trigonometric formula.

The measurement of the angle of torsion in a dried femur, as shown in Figure 3, is a simple procedure, the only real source of error being the judgment of the observer in aligning the movable bar of the goniometer with the central axis of the neck of the femur. In many readings on many femora performed by the authors, there was never more than a 5-degree variation when this method was used. When the angle of torsion is determined with roentgenograms either in the skeleton or the living subject, there are many factors involving sources of error which must be considered in order that an accurate determination may be obtained. The most important of these factors are:

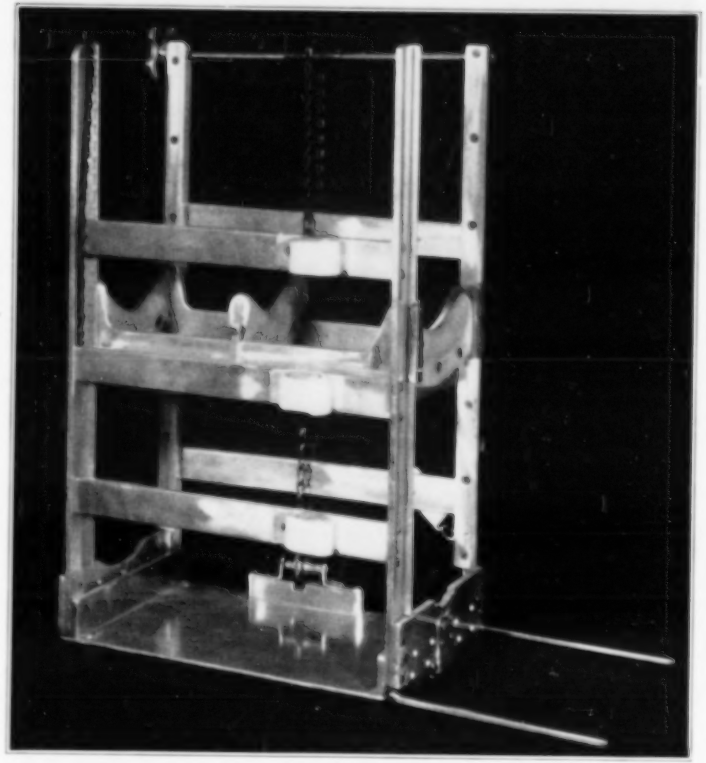


FIG. 4

Fig. 4: Positioning apparatus constructed of metal designed at the Alfred I. duPont Institute. It is twenty inches high, twelve inches long, and seven inches wide. The supporting section for the leg can be adjusted to a height from two and a half inches to nineteen inches by turning the knob in the upper left hand

(*Continued on page 297*)

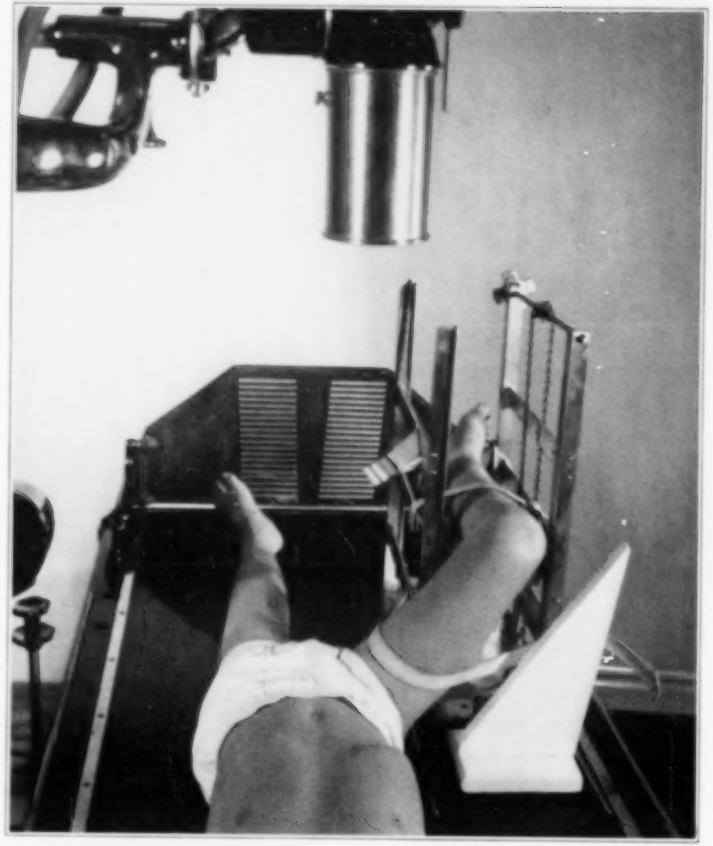


FIG. 5

(*Fig. 4: Continued from page 296*) corner. It is locked in place by the chain in the upper left-hand front corner. The arms of the U-shaped bar on the lower right-hand side of the apparatus, called the reference bar, are six inches long and seven inches apart. This bar can be moved from side to side as desired and can be fastened to the posts of the apparatus when not in use. Note the three rolled-up straps on the side bars of the apparatus which can be used to secure the leg and thigh in the apparatus.

Fig. 5: A child has been positioned in the apparatus with his leg and thigh secured with straps. Note the triangular wooden template on the right side which is used to position the thigh. The inner side of the template approximating the thigh is at a 10-degree angle to a perpendicular line to the roentgenographic table. Note the position of the inner arm of the U-shaped reference bar adjacent to the hip.

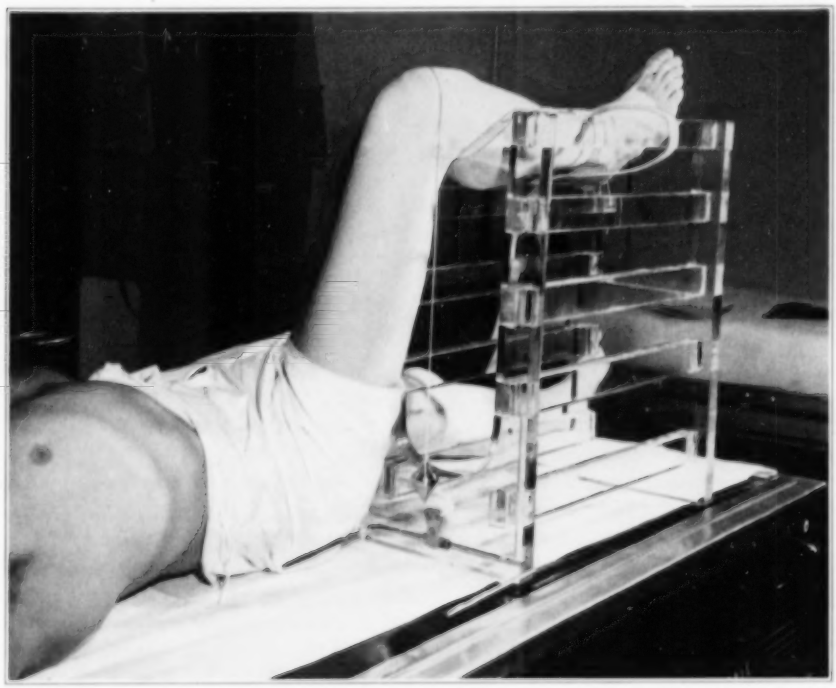


FIG. 6

A positioning apparatus similar to that shown in Figs. 4 and 5 was constructed of Plexiglas at the Madigan Army Hospital, Tacoma, Washington. The position of the leg in the apparatus is regulated by the straps which can be raised or lowered according to the length of the thigh. Note the plumb line which is used to align the thigh at right angles to the table and that the inner arm of the "U" reference bar is just lateral to the hip.

1. The amount of flexion, abduction, and rotation of the hip;
2. The angle of inclination (shaft-neck angle);
3. The angle of the roentgen ray to the film;
4. The anterior bowing of the shaft of the femur.

Some of these factors have been recognized by others working on this problem.*

Theoretically, if a roentgenogram could be taken with the roentgen ray parallel to the long axis of the proximal one fourth of the shaft of the femur so that the condyles and the head and neck were projected on the film, the angle of torsion could be measured with a certain degree of accuracy. Radiopaque metal rods placed through the transcondylar axis of the condyles and the central axis of the neck would further increase the accuracy. In the authors' method, an attempt is made to attain this ideal roentgenographic view in the living subject by the use of a simple positioning apparatus (Fig. 4).

* C. T. Ryder and Lawrence Crane of the New York Orthopaedic Hospital; J. H. Shelswell of the Royal National Orthopaedic Hospital in London; D. M. Dunn of Essex, England; and H. C. Fett, D. J. Magilligan, J. C. Barnett, and H. C. Fett, Jr., of Brooklyn, New York.

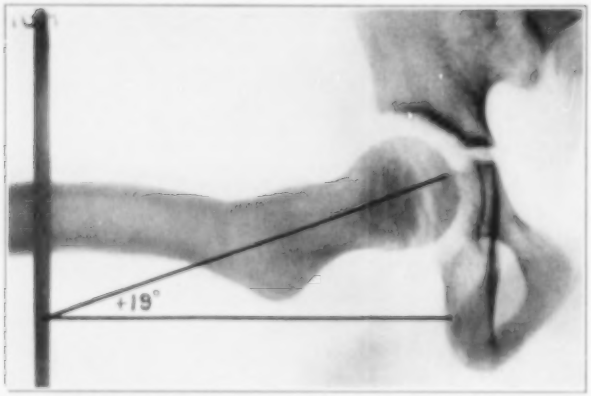


Fig. 7. A lateral roentgenogram of the right hip in the authors' position of a normal child, six and a half years old, shows the method of measuring torsion of the femur on the film. A line drawn through the central axis of the neck of the femur is projected to meet the shadow of the metal reference bar which is the reference line. At this point, a perpendicular line is erected to the reference line. The amount of torsion is the angle formed by this perpendicular line and the line of the central axis of the neck of the femur. The reading in this femur is +19 degrees which is within normal limits for this age.

FIG. 7

POSITIONING OF THE PATIENT

The first roentgenogram is taken with the patient in the prone position and is a postero-anterior view of the hips in a neutral position, that is, full extension and neutral rotation, with the knees flexed to 90 degrees, and the legs perpendicular to the cassette.* From this film, the angle of inclination (neck-shaft angle) is measured in the usual manner.

The second roentgenograms are taken with the patient in the supine position and are lateral views of each hip taken separately. The important steps in the patient's positioning for these roentgenograms are as follows:

1. With the patient in the supine position, the leg of the hip to be examined is placed on the leg support of a special positioning apparatus (Figs. 4, 5, and 6).

2. The height of the leg support is adjusted to equal the length of the thigh. This adjustment permits both the knee and the hip to be flexed to a right angle. The shaft of the femur, and particularly its proximal fourth, must be as nearly perpendicular to the roentgenographic table and film as possible. This position can be verified by passing a line through the anterior border of the external condylar ridge and the greater trochanter; if this line is at right angles to the table, the position is satisfactory. As can be seen in Figure 8, this perpendicular line bisects the proximal one fourth of the femur; this is the part of the femur which must be at right angles to the roentgenographic table for correct positioning.

3. The thigh is abducted 10 degrees. In order to be as accurate as possible in this positioning, the lateral surface of the thigh, which is parallel to the long axis of the femur, is aligned with the medial side of a triangular wooden template. This template (Fig. 5), which is perpendicular to the roentgenographic table, has a 10-degree angle**, with a perpendicular line from the table on the medial side; and it rests on a flat base.

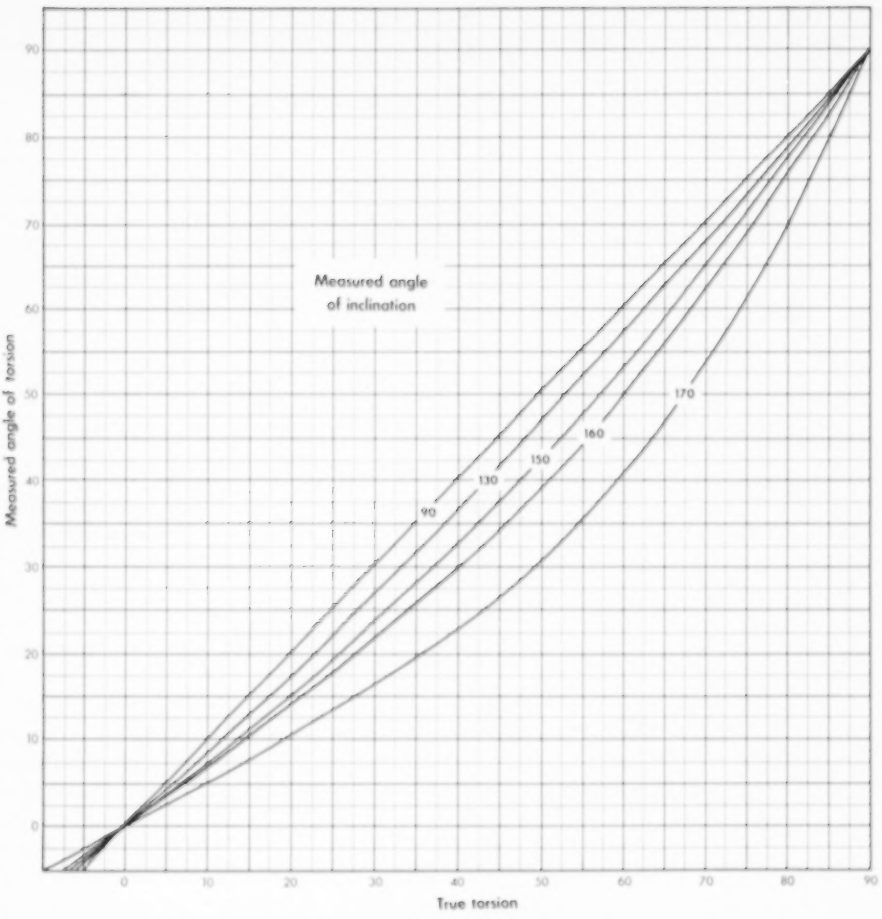
With the patient thus positioned, the tube is placed directly over the hip, and a cassette containing eight-by-ten-inch film is placed beneath the hip. In order to minimize distortion of the angles of the femur on the roentgenogram, it is most important that the tube be so placed that the central roentgen ray will be perpendicular to the plane of the film.***

With the lower extremity in the correct position, the arm of a U-shaped radiopaque metal reference bar, attached to the base of the positioning apparatus (Figs. 4, 5, and 6), is adjusted so that it is just lateral to the greater trochanter and hip. This bar automatically

* The authors believe that it is very important to take a postero-anterior roentgenogram of the hips, rather than an anteroposterior roentgenogram, as a neutral rotation can be better ensured when the legs are at a right angle to the roentgenographic table.

** Ten degrees was found to be the minimum abduction necessary to exclude from the roentgenogram soft-tissue shadows of the thigh and knee so that the head, neck, and proximal one fourth of the shaft of the femur will be clearly outlined on the roentgenogram.

*** Klinefelter, in 1946, well demonstrated the importance of this point.



GRAPH I

Graph shows the relationship of the true angle of torsion to the measured angle of torsion and measured angle of inclination from the roentgenograms. This graph is prepared from the Webber Formula No. 1, in which the angle of abduction is 10 degrees.

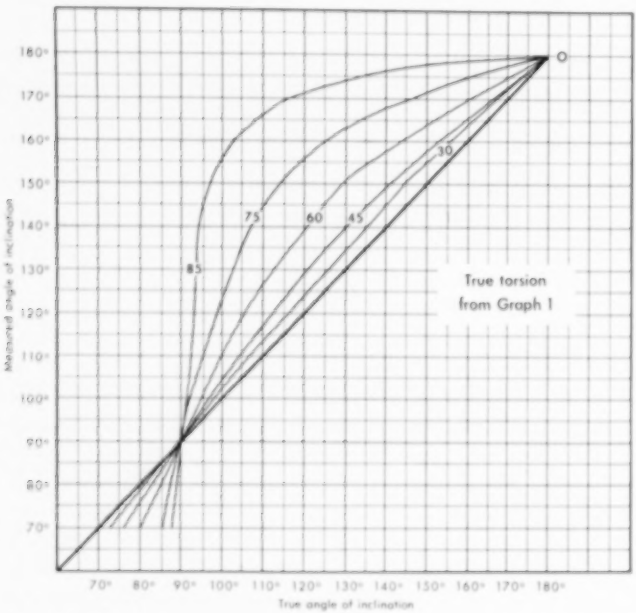
parallels the tibia and is at right angles to the transcondylar axis or frontal plane of the femur.*

THE ROENTGENOGRAMS AND GRAPHS IN THE DETERMINATION OF FEMORAL TORSION

The shadow of the radiopaque metal reference bar (lateral to the greater trochanter) is projected on to the film and becomes the reference line. A line is now drawn on the film through the central axis of the femoral neck, and it is projected until it crosses this reference line (Fig. 7). When this line is drawn, the borders of the cortex of the neck should be accurately identified. The central axis lies mid-way between these cortical borders. The femoral head, or epiphysis, is often found to be in an asymmetrical position on the neck (Fig. 1-D), and its center should not be used as one of the points for the determination of the central axis on the film. At the intersection of the central axis line of the femoral neck

* Dunn, Ryder and Crane, and Shelswell, in their studies, have used a technique similar to that described by Gaenslen in 1936 for positioning of the patient and the taking of lateral roentgenograms of two hips on the same film. The authors believe that the technique here described results in a roentgenogram with fewer possible sources of error than the Gaenslen or a modified Gaenslen technique.

and the reference line, a line is drawn perpendicular to the reference line. This line represents the transcondylar axis *, or the frontal plane of the femur (Fig. 7). The angle formed by the transcondylar axis and the femoral-neck axis is the *measured or apparent angle of femoral torsion* (Fig. 7). If the neck axis is superior to the transcondylar axis, the angle is designated a plus angle, that is, there is anteversion present (Fig. 7); if the neck axis is inferior to the transcondylar axis, the angle is designated a minus angle, that is, there is retroversion present (Fig. 1-C); and if the axis of the femoral neck is parallel to the transcondylar axis, the angle is zero, and the femur has no measured angle of torsion.



GRAPH II

Graph shows the relationship of true angle of inclination to the measured angle of inclination and true angle of torsion. This graph is prepared from the Webber Formula, No. 2.

The true angle of torsion can now be determined with mathematical accuracy from the measured or apparent angle of torsion, the measured or apparent angle of inclination, and the angle of abduction, by the use of a special trigonometric formula. This formula is designated Webber Formula No. 1 and is as follows:

$$\text{Tan } \Theta = \text{Tan } \Theta_2 \, (\text{Cos } \alpha - \text{Cot } \beta_2 \, \text{Sin } \alpha)$$

Θ = the true angle of torsion;

Θ_2 = the measured angle of torsion;

α = the angle of abduction;

β = the true angle of inclination;

β_2 = the measured angle of inclination.

In order to simplify the use of this formula, Graph I has been prepared in which an abduction angle of 10 degrees has been used; this is the amount of abduction recommended for the lateral roentgenograms. The following example demonstrates the use of Graph I:

With a measured angle of torsion of +50 degrees and a measured angle of inclination of 160 degrees, the true angle of torsion is found to be +60 degrees.

Once the true angle of torsion is determined, it is possible with the use of a second trigonometric formula to derive the anatomical or *true angle of inclination*. This second formula is designated Webber Formula No. 2 and is as follows:

$$\text{Cot } \beta = \text{Cot } \beta_2 \times \text{Cos } \Theta$$

The second formula is expressed in Graph II. An example of its use is as follows:

With a measured angle of inclination of 140 degrees and a true angle of torsion of 45 degrees, the true angle of inclination is found to be 130 degrees.*

* If desired, a radiopaque metal cross bar can be attached to the U-shaped bar at right angles to the arms of the U which will be projected onto the roentgenogram and will represent the transcondylar axis (see Fig. 13). Gross malpositioning by a technician can be checked if the image of the proximal one fourth of the shaft of the femur does not fall almost parallel to this transcondylar axis.

** Alfred Chester Webber, B. S. (Phys.), M. S. (Phys.), supervisor of the Physics Group of Polychemical

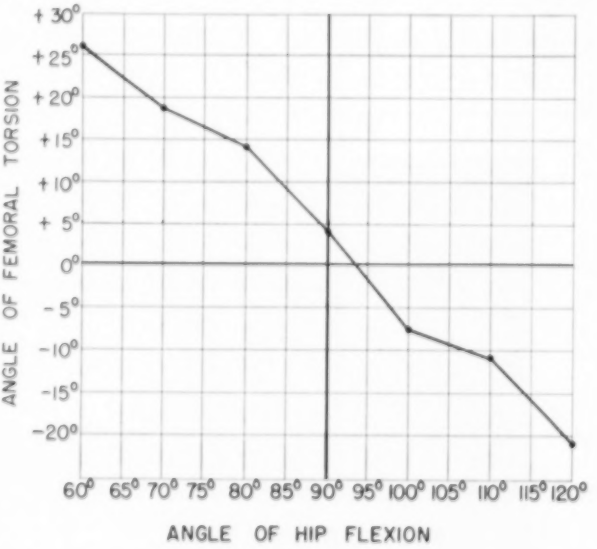
STUDIES TO CHECK ACCURACY OF METHOD AND SOURCES OF ERROR

1. *Studies on the Normal Skeleton to Check the Accuracy of Method*

The first studies were carried out on normal dried femora. These were performed to check the accuracy of the roentgenographic determinations with the anatomical measurements of femoral torsion with a goniometer. The torsions of the dried specimens were measured by using the method as shown in Figure 3 and were found to be 0 degrees, +4 degrees, and +5 degrees, respectively. Each femur was then rearticulated to the skeleton,* and a lateral roentgenogram was taken with the skeletal lower extremity positioned in the apparatus exactly as described. In repeated roentgenographic torsion determinations on these femora, the true angle of torsion of each femur was never found to be more than 2 degrees at variance with the torsion determined with the goniometer.

2. *The Effect of Flexion of the Hip on the Torsion Determination in the Normal Skeleton*

The effect of flexion of the hip upon the roentgenographically measured angle of torsion was determined on the normal skeleton. It was demonstrated that flexion of the hip of more than 90 degrees, that is, bringing the knee up towards the pelvis and abdomen from 90 degrees, causes a decrease in anteversion, or minus reading; while flexion of the hip of less than 90 degrees, that is, bringing the knee down away from the pelvis and abdomen from 90 degrees, causes an increase in anteversion or plus reading. Graph III shows that 60 degrees of flexion of the hip from the fully extended or neutral position results in a +26-degree reading; 120 degrees of flexion of the hip from the neutral position results in a −21-degree reading; and 90 degrees of flexion of the hip from the neutral position to a right angle results in a +4-degree



GRAPH III

Graph shows the angles of femoral torsion in relation to hip flexion from roentgenographic skeletal studies. When the knee is brought toward the abdomen and pelvis from 90 degrees, the amount of femoral torsion decreases, that is, the anteversion reading becomes less; when the knee is brought away from the abdomen and pelvis from 90 degrees the amount of torsion increases, that is, the anteversion reading becomes greater. The angle of hip flexion as used in this graph is measured from the neutral position or 0 degrees of flexion.

Research, at the Experimental Station of the E. I. duPont deNemours Company, Wilmington, Delaware, derived the formulae and their resulting graphs after detailed study.

In the course of verifying these trigonometric determinations, we constructed two plastic models. These models considered the following planes and angles:

A. Hip abduction;
B. Femoral torsion;
C. Angle of inclination (neck-shaft angle).

The authors were impressed by the mathematical accuracy of the formulae and graphs when clinically and experimentally applied.

NOTE: Enlarged and more detailed copies of Graphs I and II may be obtained by writing to the Alfred I. duPont Institute.

* If studies are to be made on an ordinary articulated skeleton, the usual articulations should not be used. The authors have found that normal elastic structures are satisfactorily simulated with the use of a rubber-glove hip-joint capsule with rubber collateral and cruciate ligaments at the knee.

reading. This latter reading is the torsion for this femur as measured with a goniometer. These findings clearly indicate the importance of the femur's being at right angles to the roentgenographic table and film in the positioning of the patient. If the femur is at an angle to the table greater or less than 90 degrees, the torsion determination will be incorrect.

3. *The Effect of Abduction of the Hip on Torsion Determinations in the Normal Skeleton*

Roentgenographic studies were performed to determine the effect of abduction of the hip on the torsion determination on the same three normal right femora mentioned in the first paragraph of this section, of which the angles of torsion were 0 degrees, +4 degrees, and +5 degrees, respectively. Lateral roentgenograms were taken of the hips of femora articulated to the skeleton, positioned as described in the authors' method with abduction varying from 10 to 50 degrees. It was found that there was never more than 2 to 3 degrees' variation with the same femur in the different degrees of abduction. From this study, it is concluded that in the normal femur with minimal torsion, that is, less than 10 degrees, abduction of the hip is an almost negligible factor as a possible source of error. However, this was not found to be true when the femur had more than +10 degrees of torsion, as will be demonstrated later in these studies.

4. *The Effect of Anterior Bowing of the Femur on Torsion Determinations*

The shaft of the femur normally has a small amount of anterior bowing. If, when the lower extremity is positioned and the femur is aligned, this anterior bowing is not taken

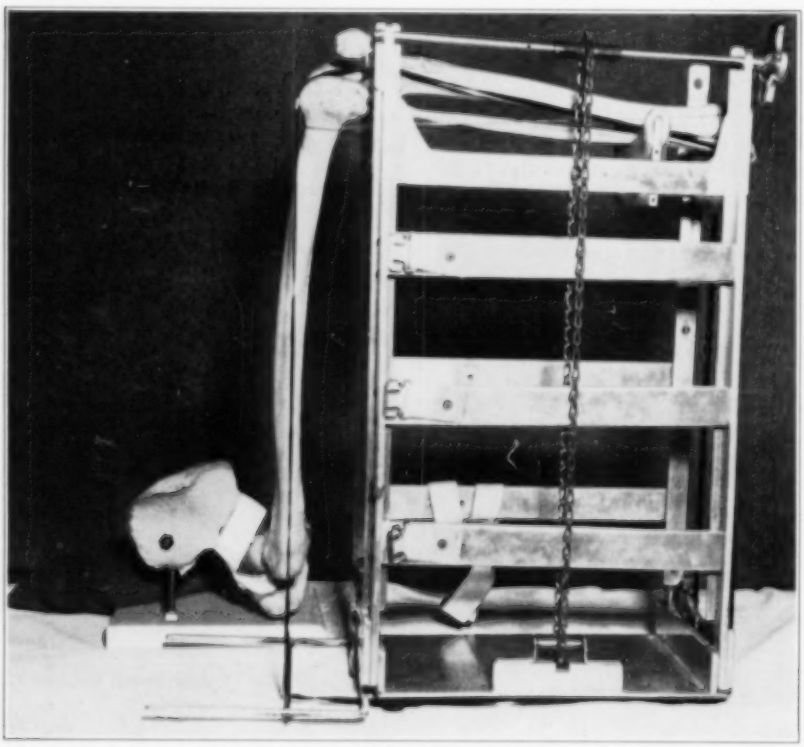


FIG. 8

Photograph is a lateral view of a normal femur in the authors' position articulated with the pelvis and leg. Note that the line perpendicular to the table bisects the greater trochanter and the adjacent one fourth of the femoral shaft, and it passes over the anterior border of the external condylar ridge. This position gives the most accurate torsion determination.

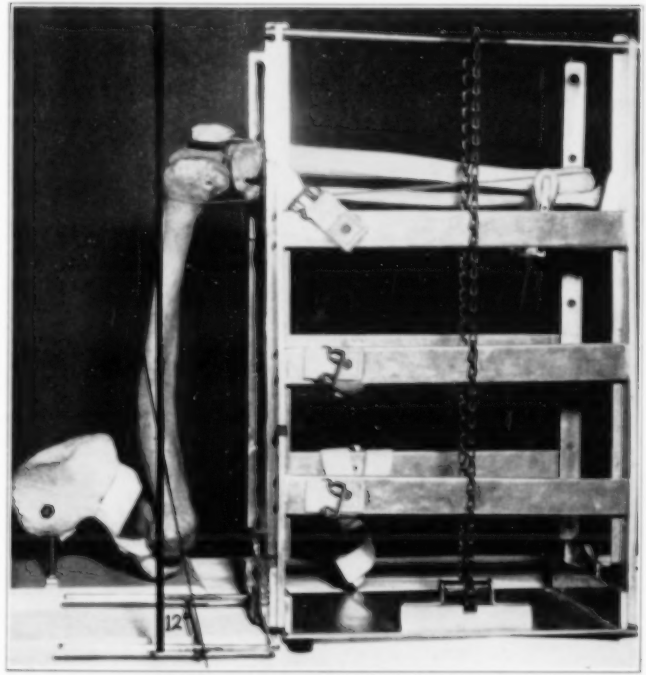


FIG. 9-A

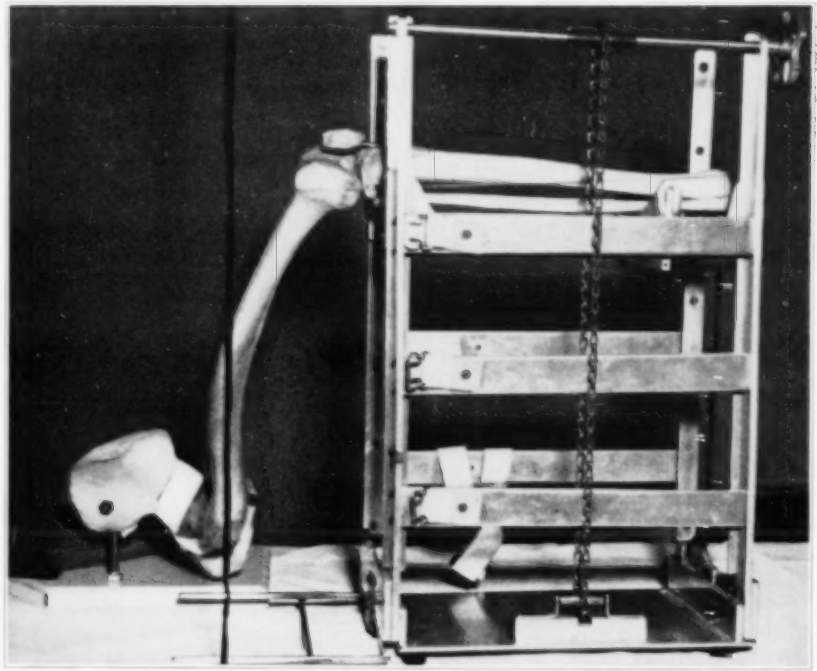


FIG. 9-B

Fig. 9-A: Lateral photograph of femur articulated in the authors' position shows excessive anterior bowing of shaft. Note that the line which is perpendicular to the table and which passes over the anterior border of the external condylar ridge is proximal to the greater trochanter and does not bisect the adjacent one fourth of the femur. In this position, the hip is flexed 12 degrees from the right angle toward the pelvis as can be seen by the angle formed by the central axis of the proximal one fourth of the femur and the perpendicular line. This amount of hip flexion is a definite source of error and would result in a decrease in the measured torsion determination.

Fig. 9-B: The perpendicular line bisects the greater trochanter and proximal one fourth of the femoral shaft. In this position, the hip is flexed 90 degrees, but the condyles of the femur are distal to the perpendicular line. A lateral roentgenogram of the hip taken in the authors' position has no error on account of faulty positioning caused by anterior bowing of the femoral shaft.

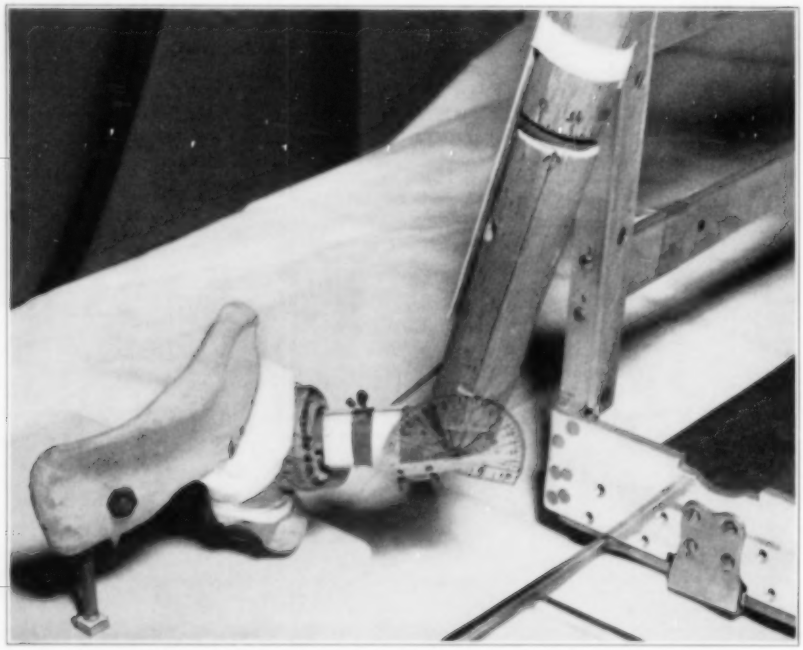


FIG. 10

An adjustable wooden femur articulated with the pelvis has been placed in the authors' position. It will be noted that the angle of inclination can be changed and accurately measured with the protractor and that the amount of torsion can be changed and measured by the scale and arrow.

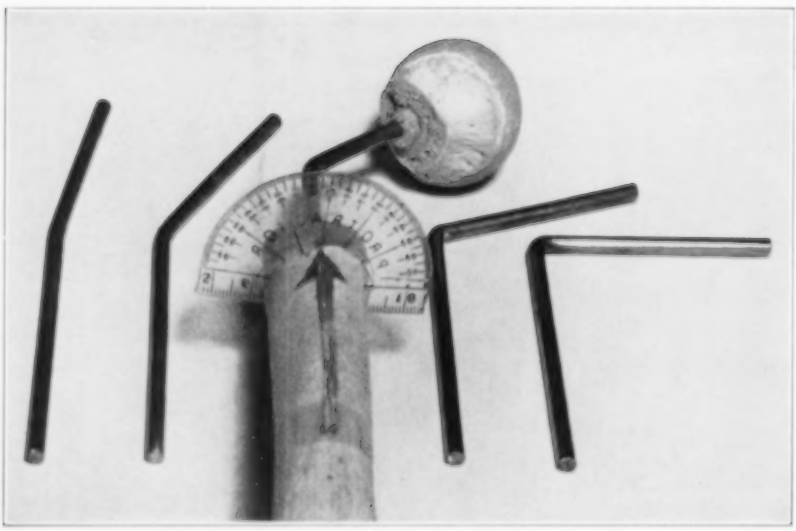


FIG. 11

A normal femur is shown in which an angulated metal rod has replaced the neck and trochanteric areas. It will be noted that on the distal side of the protractor is a small cylindrical section of bone. This section is attached to and rotates with the metal rod so that the amount of torsion can be accurately determined with the protractor and arrow. The five metal rods are at angles of 90 degrees, 110 degrees, 130 degrees, 150 degrees, and 170 degrees. These rods are interchangeable and are easily inserted into the head and shaft.

into consideration, there will be a definite error in the torsion determination. In order to obtain the correct position to ensure the minimum error, the femur should be so placed that a line perpendicular to the roentgenographic table passes through the anterior border of the external condylar ridge and bisects the greater trochanter (Fig. 8). This line, as can be seen, will also bisect the lower one fourth of the shaft of the femur. If there is an excessive amount of anterior bowing, such as is seen in Figure 9-A, and this method of alignment is used, the perpendicular line passing through the anterior border of the external condylar ridge will not bisect the lower one fourth of the shaft and greater trochanter, and there will be an error in the torsion determination. In this instance (Fig. 9-A), there will result a flexion of the hip of 12 degrees from the right angle. This amount of flexion, as can be seen in Graph III, will result in a decrease of the torsion determination. To correct the error in anterior bowing greater than normal, it is necessary to displace the knee distally to a perpendicular line through the greater trochanter which does not pass through the anterior border of the external condylar ridge, the amount of displacement depending upon the amount of anterior bowing (Fig. 9-B).

5. *Studies on Specially Constructed Femora to Check Further Sources of Error and to Check the Special Trigonometric Formula for the Correction of Error*

In order to check the angle of inclination as a source of error, to further check abduction as a source of error, and to check the special trigonometric formula for the correction of error, studies were made on the following specially constructed femora: (a) A wooden femur which allowed variation of both torsion and the angle of inclination, but the shaft of which was straight and contained no anterior bowing (Fig. 10), and (b) a normal femur with the section from the subcapital area to the subtrochanteric area replaced with a

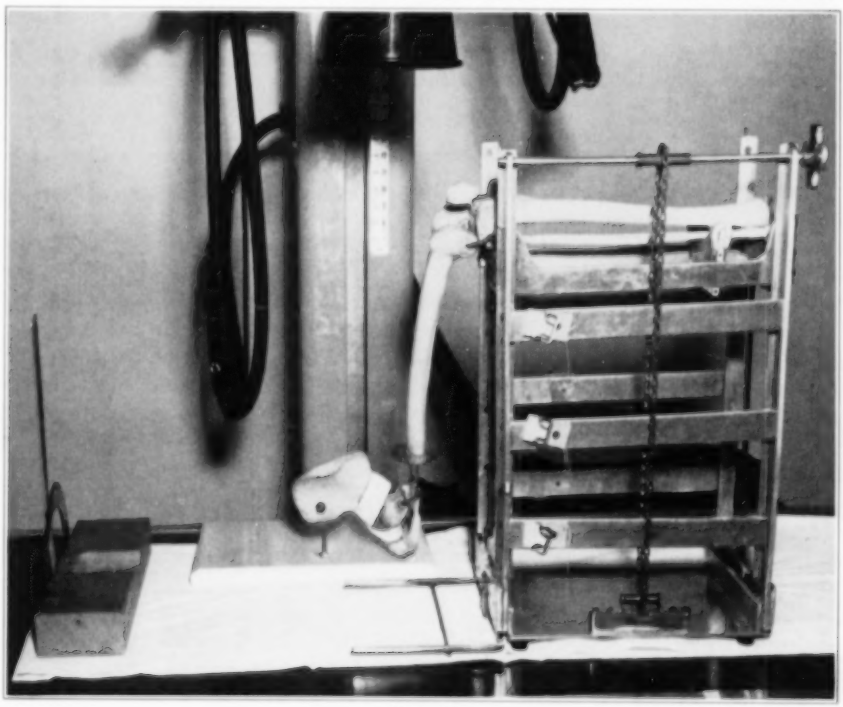


FIG. 12

An adjustable metal-rod femur has been articulated in the authors' position. The special positioning apparatus is adjusted so that the proximal one fourth of the femur is perpendicular to the roentgenographic table.

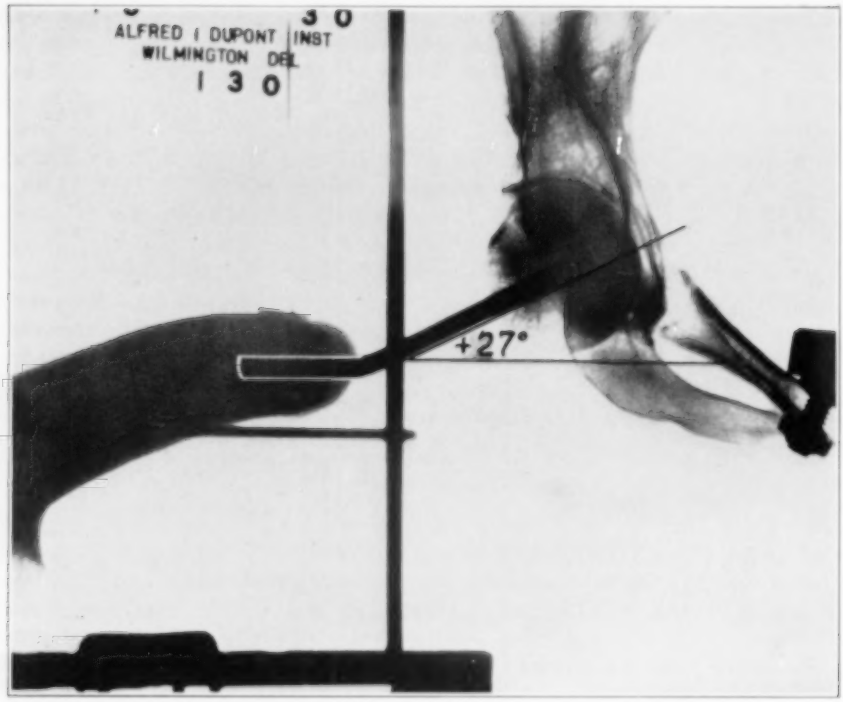


FIG. 13

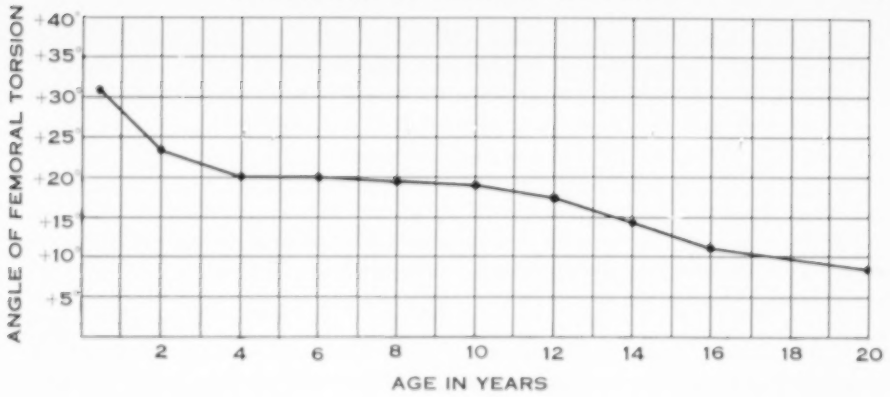
Lateral roentgenogram shows metal-rod femur articulated with skeleton in the authors' position. There is an angle of inclination of 130 degrees, an angle of fixed torsion of 30 degrees, and an angle of abduction of 10 degrees. From this roentgenogram, the measured angle of torsion is +27 degrees. Referring to Graph I, with a measured angle of torsion of +27 degrees and a measured angle of inclination of 130 degrees, the true angle of torsion was found to be 30 degrees which checks the fixed torsion. Note that the short arm of the metal rod which forms part of the proximal one fourth of the femur is parallel to the transverse condylar axis or at right angles to the primary reference bar. When this condition exists, the positioning of the femur for the lateral roentgenogram is correct.

metal rod, which could be rotated in order to vary the degree of torsion (referred to as metal-rod femur) (Figs. 11 and 12). In order to be able to vary the angle of inclination, five interchangeable metal rods were used with angles of inclination of 90, 110, 130, 150, and 170 degrees, respectively.

The adjustable wooden femur was articulated with a normal skeleton and forty-five lateral roentgenograms of the hip were made in the authors' position with combinations of (a) abduction at 5 degrees, 10 degrees, 20 degrees, 35 degrees, and 50 degrees; (b) the angle of inclination at 90 degrees, 130 degrees, and 170 degrees; and (c) the angle of torsion at +30 degrees, +60 degrees, and +90 degrees.

The metal-rod femur was articulated with a normal skeleton and twenty-seven lateral roentgenograms of the hip were made in the authors' position with combinations of (a) abduction at 10 degrees, 35 degrees, and 50 degrees; (b) the angle of inclination at 90 degrees, 130 degrees, and 170 degrees; and (c) the angle of torsion at +30 degrees, +60 degrees, and +90 degrees (Fig. 13).

In order to further check the roentgenographic findings, a photographic technique was developed with the use of the metal-rod femur. A light source of a 100-watt electric-light bulb, representing the roentgen-ray tube, was placed directly above the metal-rod femur articulated with the skeleton in the positioning apparatus. Photographic paper was placed beneath the hip in the same manner as the roentgen-ray film. One hundred and fifty photographs were made with combinations of (a) abduction at 5 degrees, 10 degrees,



GRAPH IV

Graph showing amount of femoral torsion according to age. 215 normal children (430 hips) were used between three months and sixteen years of age. There were:
16 children between 3 and 8 months with a variation of +41° to +20° and an average of +31°
39 children between 1 year and 2 years with a variation of +38° to +13° and an average of +23.7°
33 children between 2 years and 4 years with a variation of +32° to +12° and an average of +20°
30 children between 4 years and 6 years with a variation of +36° to +11° and an average of +20°
34 children between 6 years and 8 years with a variation of +32° to +7° and an average of +19.2°
31 children between 8 years and 10 years with a variation of +27° to +10° and an average of +18.4°
9 children between 10 years and 12 years with a variation of +28° to +5° and an average of +17.2°
13 children between 12 years and 14 years with a variation of +24° to +3° and an average of +14.2°
10 children between 14 years and 16 years with a variation of +26° to +5° and an average of +10.4°
100 normal adults (200 hips) were used of an average age of twenty years with an average torsion of +8.7.

20 degrees, 30 degrees, and 40 degrees; (b) the angle of inclination at 90 degrees, 110 degrees, 130 degrees, 150 degrees, and 170 degrees; and (c) the angle of torsion at +0 degrees, 10 degrees, 20 degrees, 30 degrees, 40 degrees, 50 degrees, 60 degrees, 70 degrees, 80 degrees, and +90 degrees.

In addition, two sets of metal rods attached in series in such a manner that when one moved the whole set moved were used and roentgenograms were made in varying degrees of abduction. The first was a set of six rods with a fixed angle of inclination of 130 degrees and torsion varying from −10 degrees retroversion to +60 degrees anteversion. The second was a set of eight rods with a fixed torsion of +15 degrees but with the angle of inclination varying from 90 to 160 degrees.

Typical of the data obtained from the experiments with the specially constructed femora is the information contained in Tables I and II.

The findings from the experimental studies on these specially constructed femora showed the amount of error in the measured torsion determination with the authors' method increased (1) with an increase in the angle of inclination and (2) with an increase in hip abduction, and, further, that the amount of the error in the measured angle of torsion became greater with an increase in the angle of fixed or true torsion.

The data from these experiments uniformly checked the accuracy of the special trigonometric formula (Webber Formula No. 1) for the correction of error.

PATIENT FINDINGS

Roentgenograms are reported on 1,204 hips of 499 children and 103 adults. Of these hips, 630 were in patients considered to be normal, and 574 were in patients with abnormal conditions.

1. *Reliability of Measurements in the Normal Child*

To establish the reliability of the determinations of the measured angle of torsion in the living subject, there were used three normal children of the ages of eighteen months,

TABLE I

METAL-ROD FEMUR

Angle of Inclination (*Degrees*)	Abduction (*Degrees*)	Fixed or True Torsion (*Degrees*)	Measured Torsion (*Degrees*)	Error (*Per cent.*)
90	10	+30	+30	0
110	10	+30	+29	3
130	10	+30	+27	10
150	10	+30	+24	20
170	10	+30	+16	47

TABLE II

WOODEN FEMUR

Abduction (*Degrees*)	Angle of Inclination (*Degrees*)	Fixed or True Torsion (*Degrees*)	Measured Torsion (*Degrees*)	Error (*Per cent.*)
10	130	+30	+27	10
20	130	+30	+26	13
35	130	+30	+23	23
50	130	+30	+19	37

six years, and seventeen years, with angles of femoral torsion of +14 degrees, +16 degrees, and +1 degree, respectively. The technician positioned all the patients without being checked by a physician. Lateral roentgenograms of the hips of these three patients in the authors' position were taken of each patient each day for nine days. The average standard deviation in the torsion roentgenograms was 2.4 degrees, which is considered by the authors to be within the limits of error for a determination of this character.

2. *Normal Patients*

For the normal studies, the roentgenograms of 215 children and 100 adults (630 hips) were used (Graph IV). The ages of the children varied from three months to sixteen years and the ages of the adults averaged twenty years. The average readings of thirty-two hips in sixteen children from *three to eight months of age* was +31 degrees. This figure decreased to +23.7 degrees at two years of age—the sharpest decrease in one age period. This is what might be expected as this represents the first months of normal weight-bearing. The final adult figure of +8.7 degrees is quite close to the figure of +8.02 degrees of Kingsley and Olmsted as determined in 720 dried femora.

It is the belief of the authors at this time that Graph IV represents as true a picture of the angle of torsion in the growing child and adult as can be determined by a roentgenographic method.

3. *Patients with Abnormal Conditions*

Some of the most significant variations from normal in 574 lateral roentgenograms of the hips of 287 children and adults are as follows:

A. *Congenital Dislocation of the Hip*

In twenty-nine children with a total of forty dislocated hips, the average angle of true torsion was +51 degrees. This is to be compared to an anticipated average of +20.3 degrees in these children (Graph IV). It is interesting that the average true torsion in the eighteen non-dislocated hips in the unilateral cases was +43.5 degrees. The amount of

torsion in every dislocated hip in this series was in excess of the anticipated torsion for the age. The variation in the dislocated hips ranged from a minimum of +29 degrees to a maximum of +85 degrees. In eighteen of the forty dislocated hips, there was torsion of +50 degrees or more, with ten of these hips having a torsion of +70 degrees or more.

Comment: These observations confirm the reports of most investigators. Certainly, the greatest clinical value of the determination of torsion is in the treatment of the congenitally dislocated hip. To have an accurate knowledge of the amount of torsion in the femur will be not only of assistance in determining the amount of correction which is needed in a rotation osteotomy following a reduction of the hip dislocation, but also will be of assistance in the initial decision concerning the position in which the hip should be immobilized following reduction.

B. *Coxa Plana*

A definite increase in expected torsion was present in 60 per cent. of the hips with coxa plana. The average torsion was +27.6 degrees in thirty hips with coxa plana in twenty-five children. This may be compared to an expected normal of +17.8 degrees for children of these ages (Graph IV). The average torsion in the twenty normal hips in this series was +24 degrees. In twelve of the thirty hips with coxa plana, there was torsion of from +10 to +28 degrees more than the expected normal for this age. However, on the other hand, in eleven of the thirty hips the variation from the normal was only 2 to 3 degrees, which is considered within normal limits.

Comment: Although the difference between the average torsion of the femur in the hip with coxa plana and the normal hip is not great, it is definite; and, in a few hips with coxa plana, it is excessive. It is quite possible that, due to the forward twist of the neck and shaft, abnormal circulatory changes may take place with growth of the hip. This may result in the characteristic aseptic necrosis in the upper femoral epiphysis. Proof of this may be forthcoming from the studies of the circulation of the hip in the child which, at this time, are being carried on in some orthopaedic centers.

C. *Slipped Capital Femoral Epiphysis*

In two of the four cases, there was a definite decrease in expected femoral torsion. In one of these there was a −42-degree angle of torsion in an unreduced dislocation of the epiphysis; and in the other, which was bilateral with minimal slipping, there was 0 degrees in the right hip and −2 degrees in the left hip.

Comment: With an abnormal torsion, it is likely that an increased stress may be placed upon the capital epiphyseal line and be one of the factors in a slipping of this epiphysis.

D. *Fractures of the Neck and Trochanteric Region*

There was a definite decrease in torsion, with readings of −7, −9, and +1 degrees in three cases of incomplete, or partially reduced, fractures of the neck and trochanteric region of the femur in adults.

Comment: This finding may be significant as an explanation of pain and disability accompanying an apparently good roentgenographic result.

E. *Congenitally Short Lower Extremities*

Children with one congenitally short lower extremity, aged four, ten, and eight years, revealed a definite decrease in torsion in the hip of the short extremity, with readings of +7, +1, and −10 degrees, respectively.

Comment: The authors can find no record in the literature of this observation.

F. *Other Observations*

In addition to the variations in the angle of torsion of the femur, as related to clinical conditions, many variations of the normal anatomy of the neck of the femur have been noted. A variation in the thickness and length of the neck has been repeatedly observed. Associated with an anteversion, there has been observed a curving posteriorly of the neck. This condition has been seen in what appeared to be normal hips. It has been described as *coxa anteverta* by Milch, who believes it takes place at the epiphyseal line and may be a

condition similar to slipping of this epiphysis. This may be one of the causes of congenital dislocation of the hip.

Three additional skeletal studies are now being carried out.

1. A study of the effect of valgus and varus of the knee on torsion: There is presumptive evidence that an increase in valgus will give an increase of torsion, while an increase in varus will give a decrease in torsion.

2. A study to verify the true central axis of the acetabulum: There is presumptive evidence that there may be a variation in the amount of torsion of the femur in relation to the changes in the central axis of the acetabulum.

3. A study to verify the reported anterior and posterior acetabular indices.

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TENDON TRANSPLANTATIONS IN MEDIAN-NERVE AND ULNAR-NERVE PARALYSIS *

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The purpose of this paper is to present observations on the Fowler method of tendon transplantation to restore function to the clawed fingers of a combined median-nerve and ulnar-nerve paralysis. In addition, a modification of the Fowler procedure is presented for use in those cases in which the Fowler procedure or the Bunnell multiple sublimis transplant is not applicable. The restoration of opposition to the thumb will not be discussed. The detailed anatomy of the extensor mechanism is well illustrated and explained in Duchenne's work and in Bunnell's classic volume, *Surgery of the Hand*, and will not be repeated here.

The so-called *main en griffe* deformity has been described in medical literature for many years. It has been called characteristic of many different disease processes. Actually, it represents the end result of muscle imbalance in the hand resulting from paralysis of the intrinsic muscles (interossei, lumbricales, and hypothenar muscles). Despite the frequent discussion of the *main en griffe* in the medical literature, there are few attempts to explain the development of the deformity. It should be emphasized that the deformity is the result of involvement of the median and ulnar nerves by many different etiological agents or disease processes. These include poliomyelitis, Hansen's disease, syringomyelia, Charcot-Marie-Tooth disease, and traumatic lesions. In some of these processes sensation is unaffected, while in others it is lost. In traumatic lesions, the nerves should be repaired so that some degree of sensation will return and satisfactory function will be obtained. In some of the disease processes the loss of sensation is so gradual that the patient unknowingly substitutes sight for the lost sensation and continues to use the hand despite the developing deformity. This latter type of hand lends itself readily to surgical reconstruction.

CAUSE OF THE DEFORMITY

In the typical claw-hand the long extensors and long flexors are still intact and functioning, while the intrinsic muscles are non-functioning. The dorsal and volar interossei, lumbricales, and hypothenar muscles are paralyzed regardless of the etiology of the paralysis. The resulting imbalance usually causes the gradual appearance of the claw deformity. When an attempt is made to extend the fingers, the wrist drops into some degree of flexion, the proximal phalanges go into hyperextension, and the middle and distal phalanges go into varying degrees of flexion. The loss of the flexor component of the interossei and lumbricales on the proximal phalanx is the principal loss and the cause of the deformity. It is true that some of the strength of extension of the distal two phalanges is lost, but this accounts only partly for the deformity. The unopposed pull of the long extensors on the proximal phalanges pulls the fingers into hyperextension at the metacarpophalangeal joint. This increases the tension on the flexor profundus and flexor sublimis and this, together with the partial loss of extension of the distal two phalanges from intrinsic paralysis, results in the flexion deformity of the fingers. There is also a flattening of the palm due to loss of the hypothenar muscles, but this is not functionally serious, and in our experience does not need surgical repair. As will be explained later, if the proximal phalanges are stabilized at 180 degrees of extension or less, the claw deformity will not develop.

* Read at the Annual Meeting of the American Society for Surgery of the Hand, Chicago, Illinois, January 25, 1952.

FIG. 1-A

FIG. 1-B

Fig. 1-A: Normal hand making a fist, showing normal dorsiflexion of the wrist when a tight fist is made.

Fig. 1-B: Normal hand with fingers extended, showing how wrist flexes as fingers extend.

FIG. 2-A

FIG. 2-B

Fig. 2-A: Patient with radial-nerve paralysis attempting extension. Note extension of interphalangeal joints and flexion of metacarpophalangeal joints, which is the result of unopposed action of the interossei.

Fig. 2-B: Full extension is accomplished by the interossei if the proximal phalanges are stabilized. Only extensor action on the proximal phalanges is restored by this support.

FUNCTIONAL ANATOMY

Most anatomy textbooks tell us that the interossei and lumbricales flex the proximal phalanges and extend the distal two phalanges, in addition to producing lateral motion. This leads us to believe that the long extensors can extend only the proximal phalanges, but this is not true.

Duchenne's Concept

Duchenne's brilliant observations record the true function of the long extensors. The results of his electrical stimulation of the extensor muscles define their function exactly, yet he draws the wrong conclusions from his experiments. He states that "The distal two phalanges extend on the proximal, and then the proximal phalanx extends on the metacarpals, then the metacarpals extend with the carpus on the forearm". He makes further accurate observations and states, "The instant the continuing extension reaches a position forming an angle with the forearm (hyperextension) the two distal phalanges flex on the proximal phalanges in proportion to the extension of the hand. Then, irrespective of the strongest contraction of the extensors produced by the most intense current, it is impossible to produce extension of the two distal phalanges, while the proximal phalanges continue to extend." He then wrongly concludes that the long extensors are *only* extensors of the proximal phalanges. He also records his observations on the function of the interossei

FIG. 3-A

FIG. 3-B

Fig. 3-A: Patient with median-nerve and ulnar-nerve paralysis attempting extension. Note flexion of wrist, hyperextension of metacarpophalangeal joints, and flexion of interphalangeal joints.

Fig. 3-B: Full extension is accomplished by the long extensors if the proximal phalanges are stabilized at 180 degrees or less. This support replaces flexor action of the interossei on the proximal phalanges.

FIG. 4-A

FIG. 4-B

Fig. 4-A: Median-nerve and ulnar-nerve paralysis without claw deformity. Full extension of interphalangeal joints is done by action of long extensors. Note atrophy of interossei.

Fig. 4-B: The tight anterior capsule of the metacarpophalangeal joint stabilizes the proximal phalanges, prevents hyperextension, and allows the long extensors to extend the interphalangeal joints.

and lumbricales, proving that they flex the proximal phalanges and extend the two distal phalanges, and describes their lateral movements. At that time this explanation was not accepted, but today it is in all anatomy textbooks, although in most of them the anatomy of the extensor mechanism is very poorly illustrated.

Bunnell's Concept

Bunnell's ingenious work on the function of the interossei and lumbricales showed that a synergism exists between the intrinsic and extrinsic (long extensor) muscles, and explained the motion by the "shift of the aponeurotic sleeve". This shift was supposed to determine whether flexion of the proximal phalanx or extension of the distal two phalanges takes place. He also stated that extension of the distal two phalanges is done by the intrinsics in the first half of flexion of the metacarpophalangeal joint (first 45 degrees of flexion) and that the long extensor extends the distal two phalanges in the latter half of flexion (from 45 degrees to three quarters of full flexion).

Bunnell summed it up by saying, "The gradation between the action of the intrinsic muscles and long extensor is gradual, with the balance of power changing when the proximal joints are at about 45° of flexion. There is, therefore, power of extension of the distal two joints by either the intrinsics or long extensor throughout the range . . .". He apparently believed that the long extensors are incapable of extending the distal two phalanges when the proximal phalanges are in extension, since he later stated that in fusion of the metacarpophalangeal joints the insertion of the extensor to the proximal phalanx must be cut so that it is free to extend the distal two phalanges. This is usually an unnecessary procedure, as will be explained later.

FIG. 5-A

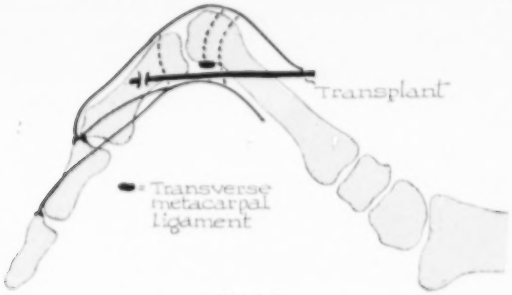

FIG. 5-B

Fig. 5-A: Fowler transplantation of the extensor indicis proprius, which has been split into two slips, and the extensor digiti quinti. Each slip is passed to the radial side of the finger.

Fig. 5-B: Side view of Fowler transplantation, showing path of tendon through the interosseous space, anterior to the transverse metacarpal ligament in the lumbrical canal, and inserted into extensor-intrinsic aponeurosis.

Fowler's Concept

Fowler's concept of finger extension was evolved in 1946. He stated that normally the distal two joints are extended by both the long extensors and the intrinsics synergistically. He further pointed out that, if the proximal phalanx is stabilized in a position of 180 degrees or less with the metacarpal, extension of the distal two phalanges may be done by either the intrinsics alone or the long extensors alone, or by both together. This is the only concept which is in agreement with all clinical and anatomical findings. It explains why the splint illustrated on page 488 of the second edition of Bunnell's book allowed the patient with median-nerve and ulnar-nerve paralysis to extend his fingers fully. The splint stabilized the proximal phalanges at a little less than 180 degrees, and the long extensor alone could fully extend all phalanges. It also explains why one occasionally sees a patient with an ulnar-nerve palsy or with palsy of both median and ulnar nerves in whom claw-hand does not develop. In such a case it is easily demonstrated that the capsule of the metacarpophalangeal joint is tight and will not allow hyperextension or very little hyperextension of this joint. Thus the long extensor is able to extend fully all phalanges.

CLINICAL APPLICATION OF BUNNELL'S AND FOWLER'S CONCEPTS

Clinically one has but to observe the various patients with ulnar-nerve lesions or with lesions of both median and ulnar nerves to see that Bunnell's and Fowler's concepts are correct. A patient with a paralysis of the dorsal interosseous branch of the radial nerve or complete radial-nerve paralysis is still able to extend the distal phalanges of the fingers. This function is due to the fact that the interossei and lumbricales are intact. If any support is given to the proximal phalanx by a mechanical device, complete extension of the finger occurs. The mechanical device merely replaces the extensor component on the proximal phalanx and does not restore the pull of the long extensor on the distal two phalanges.

In ulnar-nerve paralysis or combined ulnar-nerve and median-nerve paralysis, complete extension of the distal two joints of these fingers can be given by a mechanical block of the proximal phalanges at 180 degrees or less. The only force supplied in this case is the flexion component on the proximal phalanges. Nothing has been done to restore the pull of the interossei or lumbricales on the distal two phalanges, yet full extension occurs. Thus it is proved that the long extensor has the power to extend the distal two phalanges if the proximal phalanx is not allowed to go into hyperextension.

FIG. 6-A

FIG. 6-B

Fig. 6-A: Case M. H., girl, aged eleven. Median-nerve and ulnar-nerve paralysis resulting from laceration of all tendons and nerves on the flexor surface of the wrist six years previously. Preoperative photograph showing attempt at extension. The contracture was so severe that two months of continuous elastic traction were used to gain satisfactory extension before surgery.

Fig. 6-B: Postoperative photograph showing degree of extension possible following Fowler type of extensor transplant.

It was mentioned previously that one occasionally sees an ulnar-nerve paralysis or combined paralysis of the median and ulnar nerves without clawing of the fingers. In this type of case the capsule of the metacarpophalangeal joint is tight and the patient presents joints which will not hyperextend. In these cases the stabilizing force of the intrinsic muscles on the proximal phalanx is replaced by the stabilizing force of the tight capsule, and the long extensor is able to extend fully the distal two phalanges. This observation again proves one of Fowler's contentions; it was from such observations as these that he was able to develop his concept and devise an operation to restore extension to the fingers.

FIG. 7-A

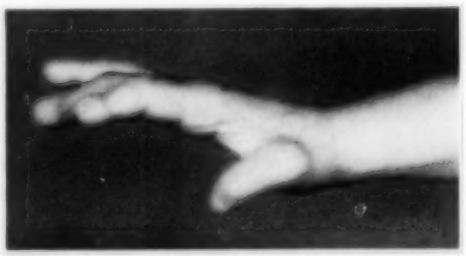

FIG. 7-B

FIG. 7-C

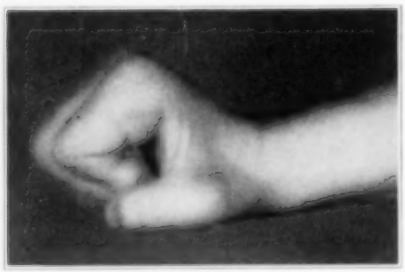

FIG. 7-D

Fig. 7-A: Case V. A., male, aged thirty-six. Preoperative photograph of median-nerve and ulnar-nerve paralysis resulting from nerve involvement by Hansen's disease. The deformity had been present for fifteen years. Note severe deformity with mild shortening of distal phalanges due to bone absorption.

Fig. 7-B: Photograph made after operation showing degree of extension possible following Fowler type of extensor transplantation.

Fig. 7-C: Photograph showing spread of fingers. This is due to the pull of the long extensors and not to the transplant.

Fig. 7-D: Photograph showing ability to make a fist.

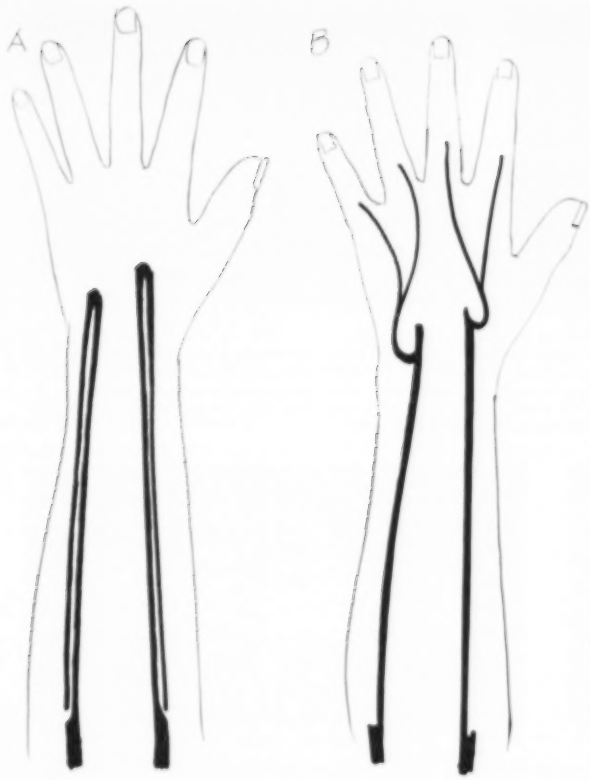

FIG. 8

Fig. 8, *A:* Schematic drawing of tenodesis procedure; one half of extensor carpi radialis longus and one half of extensor carpi ulnaris are used. Each tendon is cut one third of the distance above its insertion, stripped distally, and split into two strands.

Fig. 8, *B:* The four slips of tendon are passed through each interosseous space and inserted exactly as in the Fowler procedure.

SURGICAL REPAIR OF CLAWED FINGERS

Bunnell's Multiple Sublimis Transplantation

Bunnell's ingenious operation of transplanting multiple slips of sublimis tendons through the lumbrical canals into the aponeurotic expansion has produced excellent results in the hands of many surgeons. Bunnell implied that the success of the multiple sublimis transplantation depended upon a bed of soft gliding tissue which allowed the "gliding aponeurosis" to make the transplant both flex the proximal phalanx and extend the distal two phalanges. There is no question as to the effectiveness of this transplantation in restoring function to hands with paralysis of the intrinsic muscles. Good as this procedure is, however, it will not keep proper balance in such a hand if the deformity has been present a long time before surgical repair. The reason is that the patient has such a strong habit pattern that he will return to his old habit of flexing the wrist when he tries to extend the fingers. This immediately renders the sublimis transplants ineffective and they no longer flex the proximal phalanx; thus neither the transplants nor the long extensors can extend the distal two phalanges because the proximal phalanges are allowed to go into hyperextension.

The author has used the Bunnell multiple sublimis transplantation many times and has had excellent results with it. However, it has failed every time when it was used in cases of claw deformity of long standing. It also cannot be used in those cases with weakness or paralysis of the sublimis from any cause. The only successful operations for restoring finger extension in claw deformities of long standing are those which limit excessive volar flexion of the wrist while simultaneously limiting hyperextension of the proximal phalanges, or those which will permanently limit hyperextension of the proximal phalanges regardless of the position of the wrist.

Fowler's Extensor Transplantation

The technique of the Fowler operation requires the use of the extensor indicis proprius, which is split into two strands, as well as the two slips of the extensor digiti quinti; a slip is passed through each interosseous space anterior to the transverse metacarpal ligament and is inserted into the aponeurosis. In our experience it has been advisable to insert one slip on the radial side of each proximal phalanx in the combined extensor and

FIG. 9-A

FIG. 9-B

Fig. 9-A: Case L. E., girl, aged six. Median-nerve and ulnar-nerve paralysis and partial radial-nerve paralysis resulted from poliomyelitis at the age of two. Flail shoulder and elbow and weakness of extensors and long flexors resulted. Photograph made before operation shows attempt to make a fist.

Fig. 9-B: Preoperative photograph, showing attempt to extend fingers. Note flexed wrist and hyperextension of metacarpophalangeal joints with clawing of fingers.

FIG. 9-C

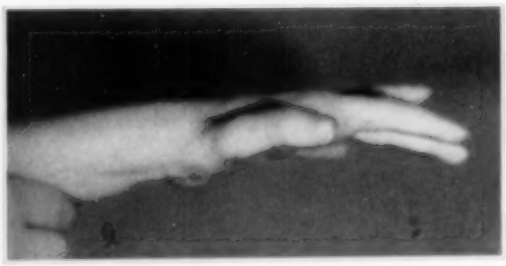

FIG. 9-D

Fig. 9-C: Postoperative photograph showing ability to make a fist. The stabilization of the proximal phalanges by the tenodesis has enabled the patient to use the long flexors of the fingers and the finger extensors to stabilize the wrist.

Fig. 9-D: Postoperative photograph, showing degree of extension after the tenodesis procedure described in Figs. 8,*A* and 8,*B*.

intrinsic aponeurosis. Several variations of the insertions on either side of the finger can be used, the extensor pollicis brevis or occasionally a sublimis tendon being employed.

The success of the Fowler transplantation depends on permanently limiting extension of the proximal phalanges at 180 degrees or slightly less. If it does this and if this can be demonstrated at the operating table, then the long extensor is capable of extending the distal two phalanges. In addition to this, it also gives a varying degree of limitation of flexion of the wrist which helps to prevent recurrence of the deformity, for as Bunnell states, "The wrist is the key joint of the hand for muscle balance".

Practically speaking, the Fowler operation may be considered as a tenodesis procedure, and serves only to limit extension of the proximal phalanges at 180 degrees or less. It is doubtful if any degree of "sliding" occurs in this operation.

TENODESIS OPERATION

Occasionally one will encounter a case of median-nerve and ulnar-nerve paralysis in which there is not sufficient sublimis strength for a Bunnell multiple sublimis transplantation, and in which the extensor side is too weak to allow the use of the extensor indicis proprius and the extensor digiti quinti. Bunnell in the second edition of his book suggested a tenodesis procedure for paralysis of the interossei. In attempting to meet this problem, the author has devised a method of tenodesis which effectively limits extension of the proximal phalanges and which has given excellent results. This was done in preference to the bone-block procedure of Howard.

In this technique one half of the extensor carpi radialis longus is cut one third of the distance above the insertion; this half is stripped distally and is left attached to the second metacarpal. One half of the extensor carpi ulnaris is likewise used and each of these strands of tendon is split into two slips. Thus there are four slips of tendon, two attached to the base of the second metacarpal, and two attached to the base of the fifth metacarpal. One slip is routed through the interosseous space and passed to the radial side of each finger; it is placed anterior to the transverse metacarpal ligament and is inserted into the aponeurosis as in the Fowler transplant. In each finger the tendon is placed under sufficient tension to limit mechanically hyperextension of the proximal phalanges at the operating table. By experience it has been found safer to put the tendons being transferred under too much tension rather than too little. A tendon which is too tight can be stretched passively to some extent, but one cannot depend on contracture to shorten a tendon which is too loose.

After operation, the hand is immobilized in a pressure dressing which maintains the wrist in dorsiflexion, the metacarpophalangeal joints in flexion, and the distal two phalanges in extension. The dressing is left undisturbed for three weeks and is then removed. Active motion of the fingers is started, but the wrist remains splinted in dorsiflexion for an additional two weeks. If the deformity has been present a long time, the wrist is left splinted in dorsiflexion until full finger function has been obtained.

The author has used the Fowler method of tendon transplantation since 1946. Exclusive of the number of procedures performed on Service personnel, seventeen operations have been performed on fourteen patients. The tenodesis operation has been performed in eight cases.

The longest period of follow-up in the series of Fowler transplantations was three years and the longest follow-up on the tenodesis procedure was one and one-half years. All of the patients had good results except for one patient with syringomyelia, who had only a fair result. The reason for the inferior result is not clear.

SUMMARY

1. The typical claw-hand deformity is caused by non-functioning interossei and lumbricales resulting from median-nerve and ulnar-nerve involvement regardless of the etiology. Function of the long flexors and extensors is still present and the resulting imbalance gradually causes the deformity to develop.

2. According to Bunnell's and Fowler's concepts of finger extension, both the long extensors and the intrinsics (interossei and lumbricales) act synergistically to extend the distal two phalanges. Fowler further states that either the long extensors alone or the interossei alone can extend the distal two phalanges, provided the proximal phalanges are not allowed to extend beyond 180 degrees.

3. Bunnell's and Fowler's concepts are partly proved by splinting in radial-nerve paralysis. Here the only force applied is extensor force on the proximal phalanges and full finger extension is possible. It is done by the intrinsic function still remaining. In combined median-nerve and ulnar-nerve paralysis, full extension of the distal two phalanges can be restored by block of the proximal phalanx at 180 degrees or less of extension, proving that the long extensors can extend the distal two phalanges if the proximal phalanges are stabilized.

4. The Bunnell multiple sublimis transplantation for paralysis of the median and ulnar nerves gives excellent results in those cases in which there are sublimis muscles suitable for transplantation and in which the deformity is of recent origin.

5. The Fowler operation for restoration of full extension in median-nerve and ulnar-nerve paralysis consists in transplanting the extensor indicis proprius and extensor digiti quinti through the interosseous space, through the lumbrical canal anterior to the transverse metacarpal ligament, and inserting it into the combined intrinsic extensor aponeu-

rosis. This procedure gives excellent results in those cases in which the sublimis muscles are not suitable for transplantation, and in which the deformity is severe or has been present for a long time. The limitation of wrist flexion resulting from this procedure is helpful in overcoming the claw deformity.

6. The same force can be exerted by a pure tenodesis operation in which one half of the extensor carpi radialis longus and one half of the extensor carpi ulnaris are used. Each tendon is split into two slips and inserted in the same manner as in the Fowler transplantation. The tenodesis procedure described here is recommended for those cases in which insufficient extensor power is present to allow use of the extensor indicis proprius and extensor digiti quinti for the Fowler transplantation and those in which the sublimis muscles are too weak for the Bunnell transfers.

7. The three methods of tendon transplantation for the correction of the claw-hand of median-nerve and ulnar-nerve paralyses discussed here can be used in nearly all cases. The only cases not suitable for such tendon transplantations are those with secondary skin contractures and fixed joint contractures; these require joint arthrodeses. It should be obvious that great care must be exercised in selecting the proper procedure for each individual case.

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DISCUSSION

Dr. Sterling Bunnell, San Francisco, California: I wish to compliment Dr. Riordan on his meticulous work on the paralyzed hands of lepers, many of which show extreme deformity, and on the excellency of his results.

First I wish to dispel any thought of difference in understanding of this complicated problem of restoring muscle balance in a finger. It is important to know all the principles and to choose those methods that are most suitable.

Fundamentally the proximal joint of a normal limb must be stabilized in extension and flexion before the tendons can properly move the distal parts, especially in the base of the finger or in the wrist joint. This is a matter of muscle balance.

Fingers with loose volar capsules cock back in their proximal joints and claw in their distal two. It is well known that the greater the cock-back, the greater is the clawing. If the nerves are injured below their branches to the flexor muscles in the forearm, the clawing is greater as the long flexor muscles are active. If the flexor muscles are adherent in the forearm, clawing is extreme. In those proximal joints with tight volar capsules, the joints remain straight. They cannot cock back and there is no need for stabilizing them in flexion.

Correction of the cocking back of the clawed finger is a necessity. I have for years given much thought to this problem. This cocking back may be so extreme in such cases of long established deformity that structural changes have set in. One of these changes is shortening of the long extensor muscle. Then when the proximal joint is held slightly flexed by tenodesis, there is a stronger effect of the long extensor to straighten the finger.

Normally the long extensor, because of its limited amplitude, extends the proximal joint strongly, the middle joint mildly, and the distal joint weakly and imperfectly. Cutting the attachments when present in the proximal phalanx gives it a greater amplitude to act on the distal two joints. The long extensor works best when the proximal finger joint is flexed from 45 to 90 degrees and less and less effectively as the proximal finger joints are straightened. To give an example of limited amplitude, when we fully flex the middle finger joints passively, we are powerless to extend the distal joints. There is considerable variation in the degree to which the long extensor can straighten the finger. In the chimpanzee there is sufficient excursion of the long extensor to extend all finger joints at once strongly and completely.

(*Continued on page 386*)

MEASURING FEMORAL ANTEVERSION: THE PROBLEM AND A METHOD

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Orthopaedists and anatomists have long found interest in the anteversion angle of the femoral neck,—the surgeons particularly in connection with its role in such pathological conditions as congenital dislocation of the hip. Both groups have contributed extensive measurement studies of the amount of anteversion in anatomical specimens largely from adults [2, 3, 4, 6, 7, 9]; the clinician, however, is faced with the problem most often in living children and needs a reliable, practical method for measuring the angle in this group. Two techniques involving fluoroscopy and rotation of the femur have been described [8, 10] and rather gross methods of clinical estimation by rotating the thigh while palpating the femoral head and trochanter are widely used [5]. Soft-tissue abnormalities which limit rotation may invalidate the measurements made by these indirect methods, while the fluoroscopic techniques, though geometrically sound, in addition are inconvenient, may be somewhat hazardous, and always require a skilled observer for their execution.

THE FEMUR: AXES, PLANES, AND ANGLES

Observing the femur, as in Figure 1, one easily recognizes the axis of the shaft and the axis of the neck, as well as the angle of inclination which they mark out. Next one needs to visualize the "transcondylar axis"; this is simply a transverse line through the condyles, as represented by a wire in Figure 1. A plane surface which includes the transcondylar axis and the axis of the shaft may be called the transcondylar plane. This plane is, then, a hypothetical flat surface passing exactly side-to-side through the femur. Viewing the bone from directly in front or behind, one sees the transcondylar plane as a surface; looking from above or below, one sees it as a line which is represented in Figure 2 by the condylar wire. The axis of the femoral neck usually inclines forward from the transcondylar plane; one recognizes the angle of anteversion as the angle between the transcondylar plane and a plane including the axes of the neck and shaft. It is seen, as in Figure 2, when looking along the axis of the shaft. The term "femoral torsion" is more descriptive than ante-

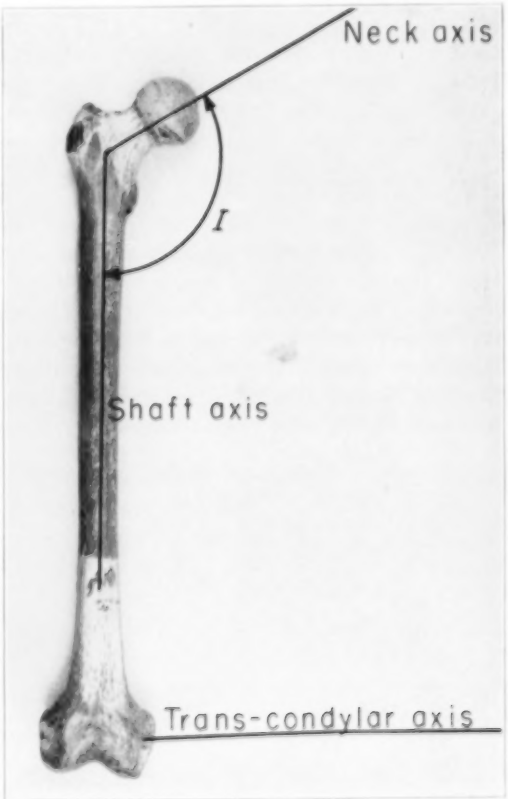


FIG. 1

Frontal photograph of femur showing axes and angle of inclination (*I*).

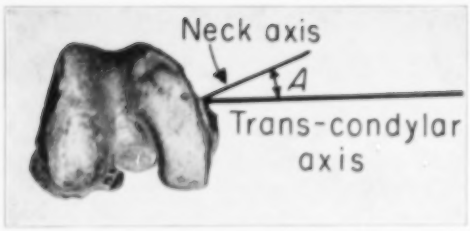


FIG. 2

Axial photograph of femur showing the angle of anteversion (*A*).

version, for indeed the angle represents the amount of twist or torsion between the upper and lower ends of the femur. Using this term, Soutter and Bradford provided the precise definition: "If two planes are revolved through the axis of the shaft until one includes the line of the condyles, the other the line of the neck, the torsion will be the difference in inclination of these two planes, *i.e.* the dihedral angle of these planes."

Some confusion in anatomical and orthopaedic literature has arisen from lack of strict appreciation of this geometric definition, which is, of course, of basic importance to any method of measuring anteversion in isolated bones or in living subjects.

THE MEASUREMENT PROBLEM

Because of its buried position, the upper end of the femur is available for anatomical investigation only by dissection or through indirect demonstration by the roentgen ray. For clinical purposes a roentgenographic method of measuring femoral torsion clearly is most desirable. The most direct method would be to place the patient on his back, flex his hip and knee to 90 degrees with 0 degrees rotation at the hip, put the film under his buttock, and make a view with the ray directed along the axis of the shaft, which would reproduce on the roentgenogram the view of the femur shown in Figure 2. Because the rays are unable to outline the neck through the mass of superimposed bone and soft tissue, such a technique is not practical. If, however, patient and x-ray equipment are positioned as before and the thigh is then so abducted that the ray strikes the neck at an angle with the shaft of 20 to 30 degrees, quite satisfactory definition of the neck is obtained (Fig. 7). This ready solution to the penetration problem immediately creates another difficulty: The angle of the neck axis with the transcondylar plane, thus obliquely projected, is no longer the true angle of anteversion. The distortion produced is clearly shown in Figures 3 and 4, in which a wire, representing the axes of the neck and shaft, has been substituted for the bony trochanter and neck. With the camera simulating the x-ray tube, photographs have been made with the femur in the equivalent of the 90-degree flexed and of the 90-degree flexed, 30-degree abducted positions. The true anteversion is of course the 62 degrees measured in the axial view; the obliquely projected angle is 46 degrees, an error of 16

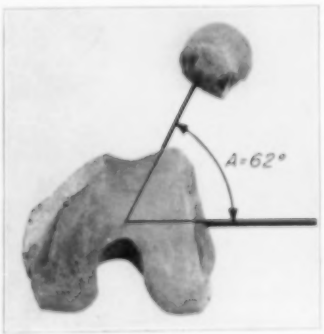


FIG. 3

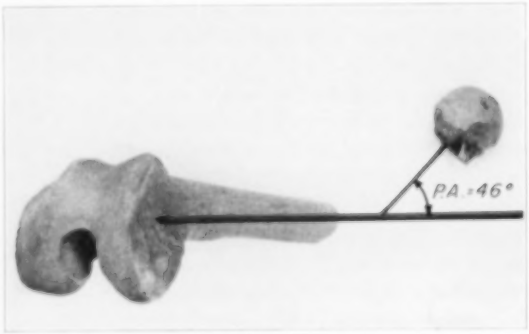


FIG. 4

Fig. 3: Axial photograph of model showing true anteversion. (See discussion of Figs. 3, 4, and 5.)
Fig. 4: Photograph made with model abducted 30 degrees from the position shown in Fig. 3, showing projected anteversion (*P.A.*).

degrees. The magnitude of this error produced by abduction is variable and depends on the true anteversion and the angle of inclination.* In the "normal" adult, with an inclination of 135 to 145 degrees and anteversion of 10 to 15 degrees, the error is numerically small—some 3 to 6 degrees. If, however, there is a high angle of anteversion and inclination—so often the case when the clinical anteversion problem arises—the error may be 30 degrees or more; this is true with any degree of abduction sufficient to give a readable roentgenogram.

The solution to this problem becomes an exercise in geometry, based on the fact that, if two roentgenographic projections of the femoral neck are obtained, each in a known fixed position, the true angle of anteversion (and of inclination) can be determined by graphic or mathematical analysis. One projection is the abduction view, already described, which gives a *projected angle of anteversion;* the other projection is a straight anteroposterior view made with the femur in neutral rotation, which gives a *projected angle of inclination.* In Figure 5, the anteroposterior view has been simulated through the use of the model femur.** For practical use, we have prepared a table and a graph with either of which, having measured the two projected angles, one can easily determine the true angle of anteversion (Table I and Graph I). The data from Table I were used in preparing the graph.

FIG. 5

Frontal photograph of model showing projected inclination (*P.I.*).

THE TECHNIQUE: PRACTICAL DETAILS

In the clinical application of these principles for measuring femoral torsion, there are four steps:

1. An anteroposterior roentgenogram is made with the femur in neutral position.

* In a recent article, D. M. Dunn has recognized and well illustrated the distortion of anteversion inherent in abduction roentgenography and has emphasized the fact that the amount of distortion is a factor of the actual anteversion. He has not discussed the fact that this distortion is also influenced by the actual inclination.

** The relationship between the various angles is given by the formula

$$\tan A = \frac{\tan a \cos (i - \Theta)}{\cos i}$$

in which A = the angle of anteversion;
a = the projected angle of anteversion;
i = the projected angle of inclination minus 90 degrees;
Θ = the angle of abduction used in making that view.

The authors wish to express their indebtedness and gratitude to Robert L. Taylor, Ph.D., of the Columbia University Department of Mathematics, whose independent analysis confirmed the geometric basis of this method, and who contributed a very complex general analysis which describes the angular relationships for all possible positions of the femur.

projected inclination \ projected anteversion	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
80	0	3	7	12	16	20	24	29	33	38	43	47	53	59	65	71	77	84	
90	0	4	9	13	17	22	27	31	36	41	46	51	56	62	67	73	79	84	
95	0	5	9	14	18	23	28	32	37	42	47	52	58	63	68	74	79	85	
100	0	5	10	14	19	24	29	34	39	44	49	54	59	64	69	74	80	85	90
105	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
110	0	5	10	16	21	26	31	36	41	46	51	56	61	66	71	76	80	85	90
115	0	5	11	16	22	27	32	38	43	48	53	57	62	67	72	76	81	85	90
120	0	6	11	17	23	28	34	39	44	49	54	59	63	68	72	77	81	86	90
125	0	6	12	18	24	30	35	41	46	51	56	60	65	69	73	78	82	86	90
130	0	6	13	19	25	31	37	42	47	52	57	62	66	70	74	78	82	86	90
135	0	7	14	20	27	33	38	44	48	54	58	63	67	71	75	79	83	86	90
140	0	7	14	21	28	34	40	46	50	56	60	64	68	72	76	80	83	87	90
145	0	8	16	23	30	36	42	48	53	58	62	66	70	74	77	80	84	87	90
150	0	9	17	25	32	39	45	50	55	60	64	68	72	75	78	81	84	87	90
155	0	10	19	27	35	42	48	54	58	63	67	70	73	77	79	82	85	87	90
160	0	11	22	31	39	46	52	58	62	65	70	73	76	78	81	83	86	88	90
165	0	13	26	36	45	52	57	62	66	70	73	76	78	80	82	84	86	88	90
170	0	18	33	45	53	60	65	69	72	75	77	79	81	83	84	86	87	89	90
175	0	29	48	59	67	71	75	77	79	81	82	84	85	86	87	88	89	89	90
180	0	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90

ANTEVERSION

TABLE I

Since the formula (page 323) defines the relationship of the true angle of anteversion to the projected angles, the data contained in Table I were most readily obtained by substituting all the various possible values for a and i, solving for A in each case. Empirical tests were made in three ways:

1. The wire model was used, as in Figs. 3, 4, and 5, with various combinations of anteversion and inclination in about ten tests. With this simple structure positioned precisely, the data check exactly.

2. Measurements were made on five dry adult femora and on two children's femora. (More tests on adult bones seemed superfluous, since the available specimens were "normal" and had nearly the same angular characteristics.) Here the maximum discrepancy between the anteversion as determined by the x-ray method and as directly measured on the bone (5 degrees) seemed well within the magnitude of reasonable error of the latter measurement. This test, like the first test, is verification for the geometric method and the data obtained mathematically; it is not a confirmation of the accuracy of the method in the living—the dry femur being much easier to position than the wiggling child.

3. In a few cases we have compared the findings at open reduction for congenital dislocation of the hip with the preoperative determination of anteversion. It is, of course, not possible to make an accurate measurement of a bone under surgical conditions, but the estimate has been in good agreement with the preoperative measurement of anteversion by our method.

2. The roentgenogram of the hip with the hip and knee flexed 90 degrees and the thigh abducted 30 degrees is made.

3. Lines representing the axes of the neck and shaft are drawn on the developed anteroposterior film.

4. Lines representing the axis of the neck and the transcondylar plane are drawn on the abduction film. The two projected angles are then measured with a protractor (Figs. 7 and 8).

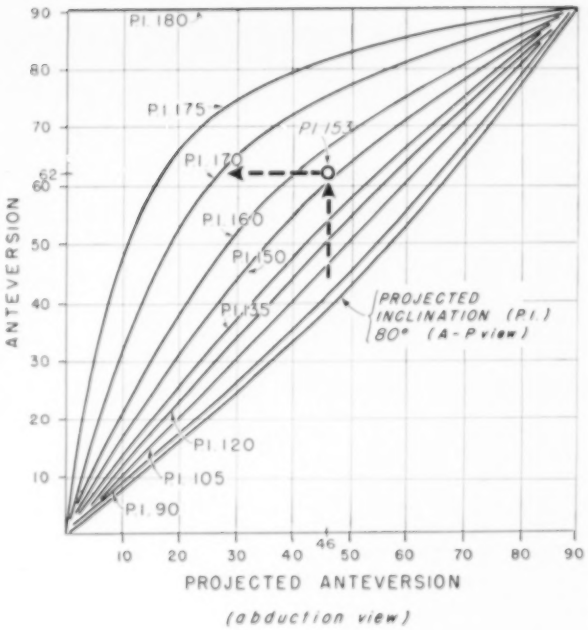
The true angle of anteversion is determined by reference to the graph or table.

MAKING THE ROENTGENOGRAPHIC VIEWS

Reasonably accurate determination of anteversion requires that the positioning of the femur for both roentgenograms be rather precise, which clearly is not easy in actual practice.

1. *The anteroposterior view:* To obtain this projection, we have placed the patient

on his back with his knees flexed 90 degrees over the edge of the table and his leg aligned with the (vertical) table leg. If necessary, support is placed under the knee so that the lateral epicondyle and trochanter are the same distance from the table top. Due allowance in positioning the leg is made in the presence of significant knock-knee or bow-leg. In this position, the transcondylar plane is held parallel to the table top; this ensures neutral rotation. The film is placed beneath the buttock and the exposure is made with the tube centered above the hip (Fig. 6).



GRAPH I

Graph used to determine true anteversion from the projected angles. Broken guide lines illustrate how the projected angles of the model (Figs. 4 and 5) are used to find the true anteversion seen in Fig. 3.

2. *The abduction view:* To secure the patient in position for this projection, one of us (L.C.), in 1948, constructed the frame illustrated in Figure 8. This frame consists of two sections made of masonite, one the mirror image of the other. These sections are held together by transverse metal bars with several set screws. The frame, consequently, is adjustable so that any pelvis from the age of several months to five years can be easily fitted. The thighs, legs, and feet are strapped into place with the thighs at 90 degrees to the pelvis and the legs at 90 degrees to the thighs. With five to ten pounds of lead set in the frame, the most active child is held immobile. The plate is placed under the frame and the roentgenogram made from above the hip, the rays thus being directed along the transcondylar plane. A metal bar incorporated in the frame transversely parallels this plane and represents it in the developed roentgenogram (Fig. 7).

(In each projection, both hips may be taken simultaneously on one film, the tube being centered at the mid-point between the hips. If a tube-to-plate distance of thirty-six inches or more is used, no significant error is introduced by the fact that the tube is not directly above the joint.)

Drawing the Axes

The accurate locating of the axis of the femoral neck in these roentgenograms is a problem which varies with the age of the subject. Before the capital epiphysis has appeared, it is very difficult or impossible; in a patient nine to fifteen months of age, one can recognize with reasonable sureness the needed axis. We have done this by bisecting the width of the neck, or the neck and head, at two separate points and by drawing a line through the two mid-points, although usually the simple drawing of the axis "by eye" gives the same placement.

The locating of the axis of the shaft on the anteroposterior film would be difficult in the presence of appreciable lateral bowing, but we have not encountered this problem in the children we have studied.

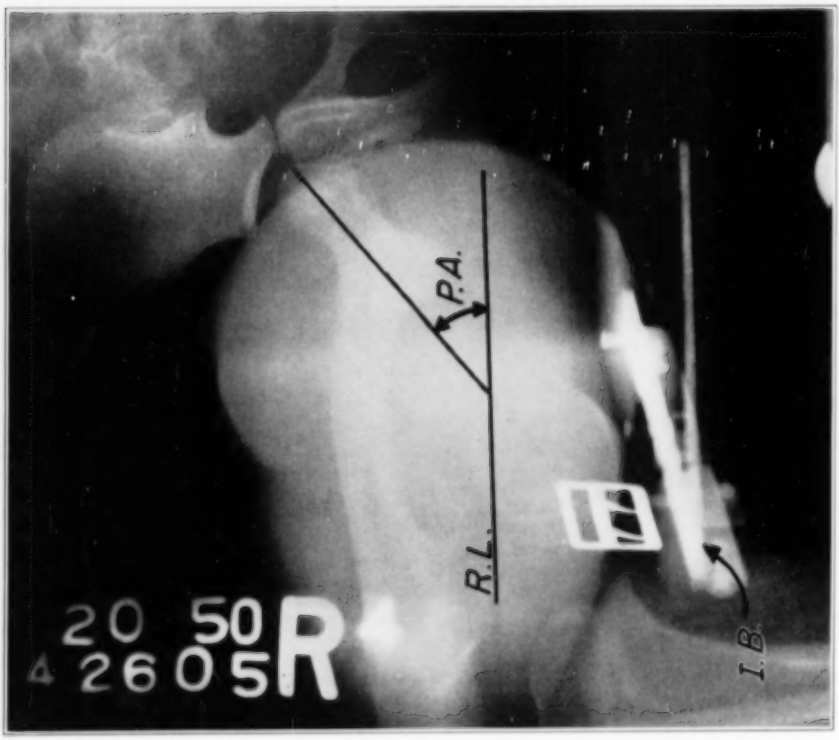


FIG. 7

Abduction roentgenogram showing projected anteversion (*P.A.*). *I.B.* is the indicator bar incorporated in the frame. *R.L.* is a reference line drawn parallel with the indicator bar, so as to intersect the neck axis at a convenient place for measurement.

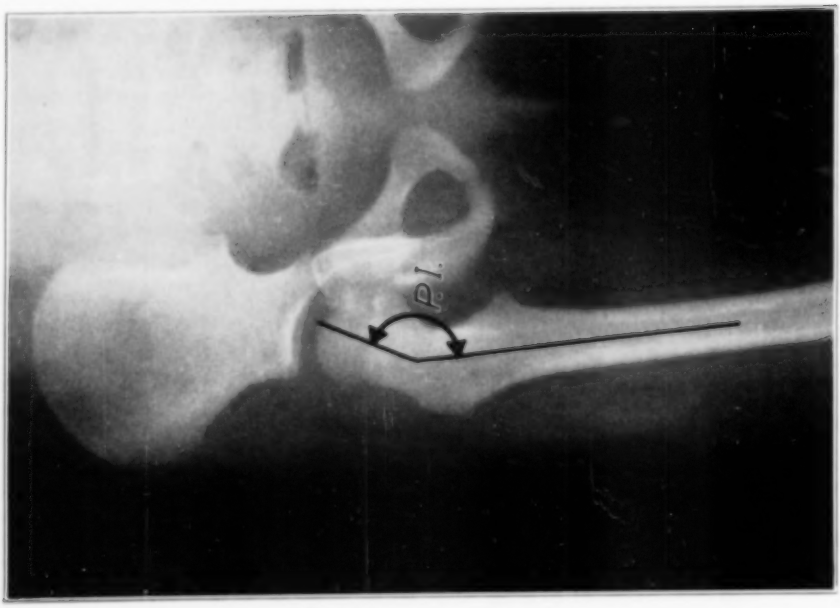


FIG. 6

Anteroposterior roentgenogram showing projected inclination (*P.I.*).

Using the Graph

Having measured the projected inclination (*P.I.*) and the projected anteversion (*P.A.*), one simply locates the *P.A.* on the horizontal axis of the chart, runs upward from this point to meet the particular curve for the measured *P.I.*, interpolating if necessary; then one reads across from this point to the vertical axis of the chart to find the true angle of anteversion (*A*) (Fig. 6). In using the table, one intersects the column headed by *P.A.* with the row headed by *P.I.*, interpolating as necessary.

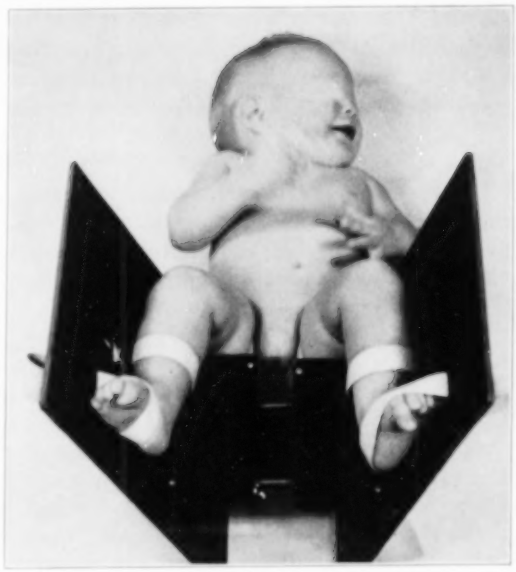


FIG. 8

Frame used in making the abduction roentgenogram.

ERRORS

Anteversion measurements made through the use of this technique are subject to error from two sources: (1) inaccurate positioning of the patient when the roentgenograms are made and (2) inaccurate location of the axes on the roentgenograms.

1. Unquestionably it is too much to expect the femur in a living child to be precisely in the desired position for these x-rays, even with the mechanical aid of the abduction frame. In the anteroposterior view, the femur may be somewhat flexed or extended, or it may be rotated internally or externally. In the abduction view, positioning mistakes may result similarly from flexion, extension, and rotation, as well as from abduction either more or less than the specified 30 degrees.

At present there is no way of recognizing malpositions from the anteroposterior film. In the abduction view, however, flexion or extension are revealed when the femoral-shaft shadow is not essentially parallel with the indicator bar shadow. Similarly, when a line connecting the posterior surfaces of the condyles is not parallel with the indicator bar, a rotational malposition has been present. If these signs are found, the roentgenogram must be made again.

The positioning mistakes, then, which are not apparent on the roentgenograms are: (1) too much or too little abduction in making the view, (2) in the anteroposterior view, flexion or extension, and (3) rotation. Assuming positional errors of ± 10 degrees (that is, the bone being at either extreme of a 20-degree arc centered at the correct position), and using the general formulae, we have computed that the maximum error in the anteversion determination will be about 10 degrees for the abduction malpositioning, about 5 degrees for the flexion-extension malpositioning, and about 15 degrees for the rotational malpositioning. If two or three such errors are present, they may tend to neutralize each other or to be additive. The anatomical circumstances permitting these maximal errors are different in the case of each error and in general would be encountered only in an extraordinary bone, so that we believe it is reasonable to say that, if the method is carried out carefully, the error in anteversion determination, resulting from positional mistakes when the roentgenograms are made, should rarely be as much as 15 degrees. On the other hand, we think it unrealistic at present to credit the technique with an accuracy of better than ± 10 degrees in routine practice.

2. The problem of locating the axes on the roentgenograms has been discussed pre-

viously. The error in anteversion determination resulting from this source is largely a factor of the state of bone development, modified by the geometry of the particular situation. The working rule is that the more uncertain the placement of the axes on the roentgenograms, the more the estimated possible error should be increased.

DISCUSSION

We have made anteversion measurements in about 200 subjects, including "normals" and patients with abnormal hips (of which most were congenitally dislocated). Most of these studies were done concurrently with our increasing appreciation of the geometric complexities of the problem, and are not, we feel, sufficiently accurate to justify publication at this time.

Our primary purpose in this paper has been to describe the principles of a geometrically sound, as well as practical, roentgenographic method of measuring femoral torsion. The actual technique in its present state of development is certainly open to improvement. There is a need for refinement in the positioning apparatus, with modifications to improve the preciseness and to reveal more surely positional errors in both the roentgenograms. The use of intra-articular radiopaque materials to define the femoral neck in the study of the very young warrants investigation. We hope that we and others may perfect the technique, to the end that reliable information about femoral torsion in children, both normal and abnormal, may finally become available.

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A STUDY IN THE USE OF BANK BONE FOR SPINE FUSION IN TUBERCULOSIS *

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This study constitutes a critical review of twenty-one patients operated upon at Sea View Hospital in an attempt to secure arthrodesis of the spine. On each patient fusion was done, bank bone being used; and, on a separate occasion, fusion with the use of fresh autogenous bone. Thus we have here a controlled clinical study in twenty-one people, contrasting the use of frozen homogenous and fresh autogenous bone grafts.

A total of seventy-one fusion procedures were performed on these twenty-one patients. Of these seventy-one procedures, twenty-six were done with bank bone and forty-five with fresh autogenous bone. In some the initial fusion procedure was performed with the use of bank bone and in others the initial procedure was done with autogenous bone.

Calculations of pseudarthrosis percentages were based on the total number of interspaces freshly covered (that is, for the first time) and the number of pseudarthrosis interspaces which developed. There were 239 fresh spaces covered; of these, 104 were with bank bone and 135 with autogenous bone. Thirty-four pseudarthrosis intervals developed after the use of bank bone and eighteen pseudarthrosis intervals with fresh autogenous bone. Therefore, there was failure of 32.7 per cent. with bank bone and failure of only 13.3 per cent. with autogenous bone. The average number per operation of new or fresh interspaces covered with bank bone was four, and the number of those covered with fresh iliac bone was three; the length of fusion, therefore, could have had but little influence on the results.

To claim that the high percentage of failures with bank bone was due to the fact that the bone was not always of the best quality (that is, cortex rather than cancellous) is pointless, since, when one uses bank bone, one takes what is at hand or goes without.

Furthermore, the bone used in these cases was from a thoroughly accredited bone bank. The specific type of bone used in each case was not recorded. Since fresh autogenous bone was available for all of these patients, it is evident that the quality of bank bone used was at the time considered satisfactory. The only consideration leading to the use of the bank bone was the saving of time and of an extra operative incision. Moreover, since a meticulous fusion by the Hibbs technique preceded implantation of the bank bone, it may be questioned whether or not such implantation added anything to the chance of securing fusion.

It was routinely noted that, in the cases in which fusion did occur with either method, the fusion in those with bank bone (Fig. 1-A) was less in thickness than the fusion in those with fresh autogenous bone (Fig. 1-B). Where pseudarthrosis did occur, those with bank bone (Fig. 2-A) tended to show marked absorption of grafts, while those with fresh autogenous bone (Fig. 2-B) usually showed merely a break in continuity. (The illustrations used are from average cases, neither the best nor the worst cases.) In no instance where fresh autogenous iliac implants had been made were we able to find sequestrated unchanged fragments of dead bone. Such fragments were found, however, after bone-bank grafts had been implanted, usually lying in dense scar tissue. On section (Fig. 3), such bank-bone fragments showed dead bone cells. Whatever the cause, the important

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 30, 1952.

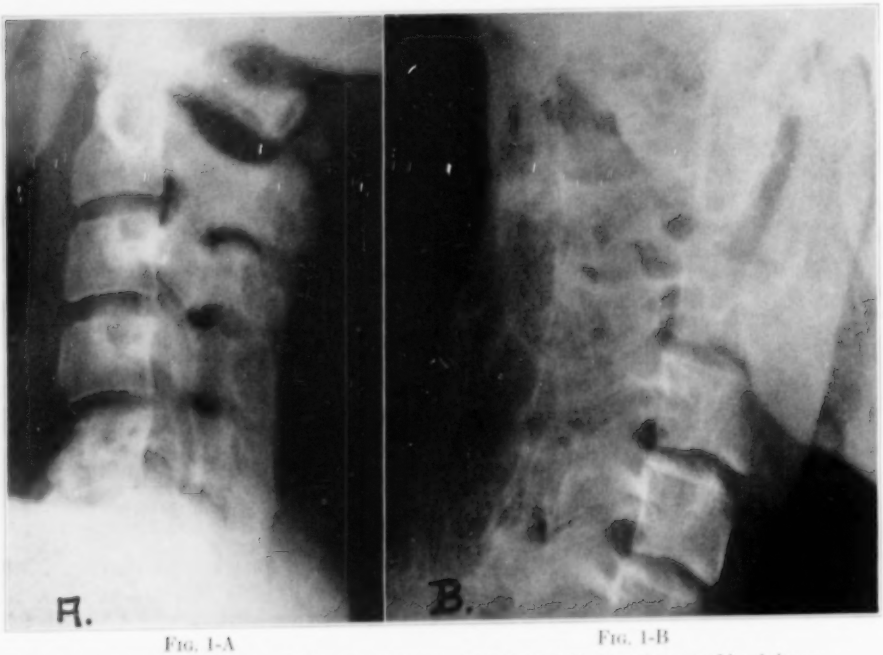

FIG. 1-A FIG. 1-B

Fig. 1-A: Showing the sparse fusion which occurred routinely following the use of bank bone.
Fig. 1-B: The relatively massive fusion seen here generally formed when fresh iliac bone was implanted.

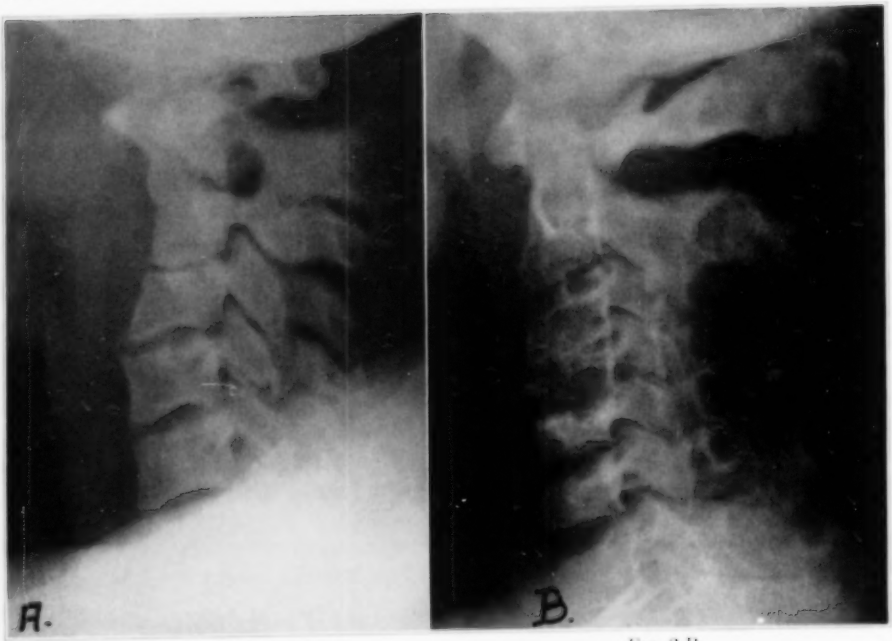

FIG. 2-A FIG. 2-B

Fig. 2-A: Showing almost complete absorption of the chips used in attempt to secure an occipito-cervical fusion.
Fig. 2-B: Showing the massive graft remaining from implanted fresh iliac bone. The fresh iliac bone has remained and has merely cracked or broken at the pseudarthrosis site, in contrast to the tremendous absorption of material occurring with bank bone.

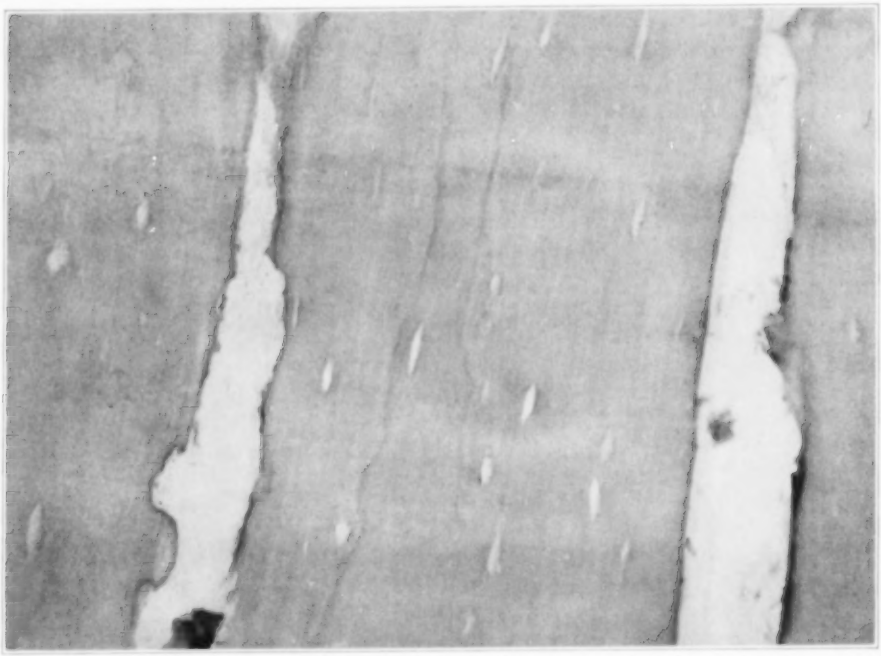

FIG. 3

Photomicrograph of bone fragments removed one year after operation. No infection or other abnormal complication had occurred. Dense scar tissue had surrounded the fragments which at operation appeared dead. Note that there are no living cells in the lacunae.

fact is that in this series, in the same patients, almost three times the number of failures did occur with bank bone as with autogenous bone.

The results from hemifusion as compared with bilateral fusion showed no effect in the pseudarthrosis rate which could be considered noticeable or of statistical significance.

Calculations were further made on the efficiency with which bank bone or autogenous fresh bone could be used in the repair of pseudarthroses developing in the fresh interspace fusions mentioned above.

Of the fifty-two interspaces in which pseudarthroses developed, eighteen were repaired by using bank bone and seventeen by the use of fresh autogenous bone. Seventeen interspaces were not repaired, either because of refusal of the patient to undergo further surgery or because the pseudarthrosis existed outside any evidence of bone destruction. There were six failures with bank bone (33.3 per cent.) and two failures with autogenous bone (11.8 per cent.). Of these eight failures, five were re-repaired with autogenous bone and all became solid. Three have not been re-repaired to date.

ASSOCIATED TUBERCULOUS DISEASE AND COMPLICATIONS

In the twenty-one patients of the series, there was roentgenographic evidence of tuberculosis in all lesions operated upon. In seven, proof was obtained by positive cultures from draining sinuses, abscesses, or by tissue section. In ten others, the operative diagnosis was confirmed by associated positive chest lesions or other proved lesions. In only four was the typical roentgenographic diagnosis not otherwise substantiated.

Ten of the patients had active pulmonary tuberculosis on admission. Nine of these patients are in good condition as regards the chest disease at the present time, with their pulmonary lesions arrested. One patient signed out against advice and returned

with draining sinuses. He died of amyloid disease. One patient is in poor condition at the present time with widespread osseous tuberculosis. One child in the group is mentally deficient as a result of tuberculous meningitis. His meningitis was arrested with streptomycin and his general physical condition is excellent at the present time. Twelve other skeletal tuberculous lesions were present in these patients, in addition to their spinal lesions.

At present, of the twenty-one patients, fourteen are fully recovered, have solid fusion of their diseased areas, and have been discharged. Four patients are convalescing and are in good general condition with a favorable outlook. One patient died and one will probably die.

Since bank-bone and autogenous fusions were done on the same patients, it is evident that the control of all factors which might influence results was perfect — a better clinical experiment, even if planned, could not have been devised. Each adult patient received one gram of streptomycin per day and each child was given one-half gram a day until the fusions were solid, his disease was considered arrested, and he was ready for discharge. All received the same high-caloric, high-vitamin diet and general care, and were handled by the same personnel.

SUMMARY

1. Twenty-one patients on whom fusions have been done with bank bone and with fresh iliac bone have been studied to determine the efficacy of each procedure.

2. The pseudarthrosis rate, as calculated by vertebral interspaces covered, was almost three times as high with bank bone as with autogenous fresh bone.*

3. In the repair of pseudarthroses, the failure rate of bank bone was three times that of fresh autogenous bone.

4. The fact that bank-bone implantation gave no higher rate of pseudarthrosis we believe to be due to the accompanying meticulous Hibbs type of fusion.

5. Bilateral spine fusion as compared with hemifusion gave no statistical advantage.

* All bank-bone fusions were done by Dr. John Cobb, whose technique in spine surgery is unquestioned. The autogenous bone fusions were done by four junior surgeons. Despite this, the results with autogenous grafts excelled those with bank bone.

EXPERIMENTAL STUDY OF THE FATE OF BONE GRAFTS *†

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The purpose of this study is to evaluate fresh autogenous, fresh homogenous, and preserved-bone grafts in the experimental animal.

Recent work by Reynolds and Oliver in 1950 on merthiolate-preserved bone and by

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† This investigation was supported by a research grant from the National Institute of Health, Public Health Service.

FIG. 1-A

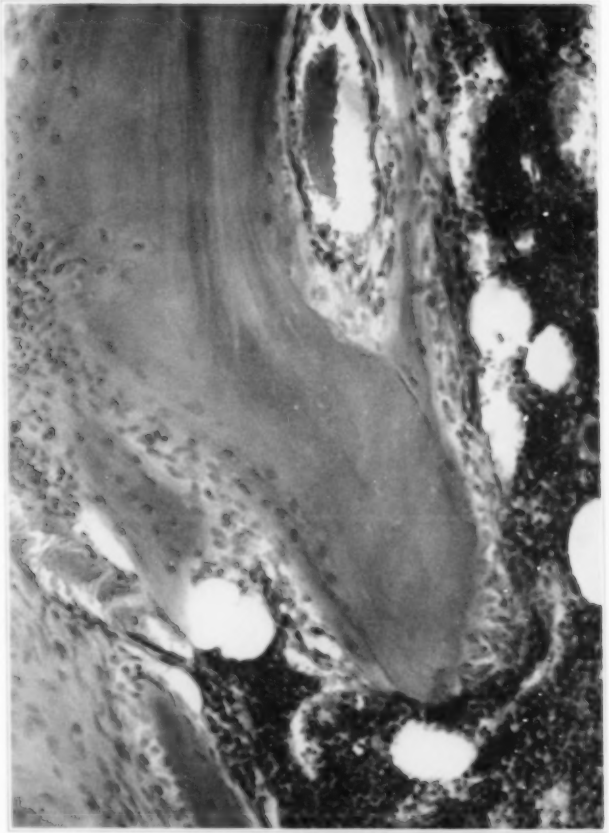

FIG. 1-B

Fig. 1-A: Fresh autogenous bone three weeks after implantation into muscle (× 55). A section through the center of the graft shows preservation of some areas of hematopoietic marrow. Osteoblastic activity is present along portions of the cortex, some Haversian systems, and the margins of trabeculae in cancellous bone.

Fig. 1-B: Fresh autogenous bone (× 215) three weeks after implantation into muscle. The osteoblastic activity along the margin of the trabeculae is evident.

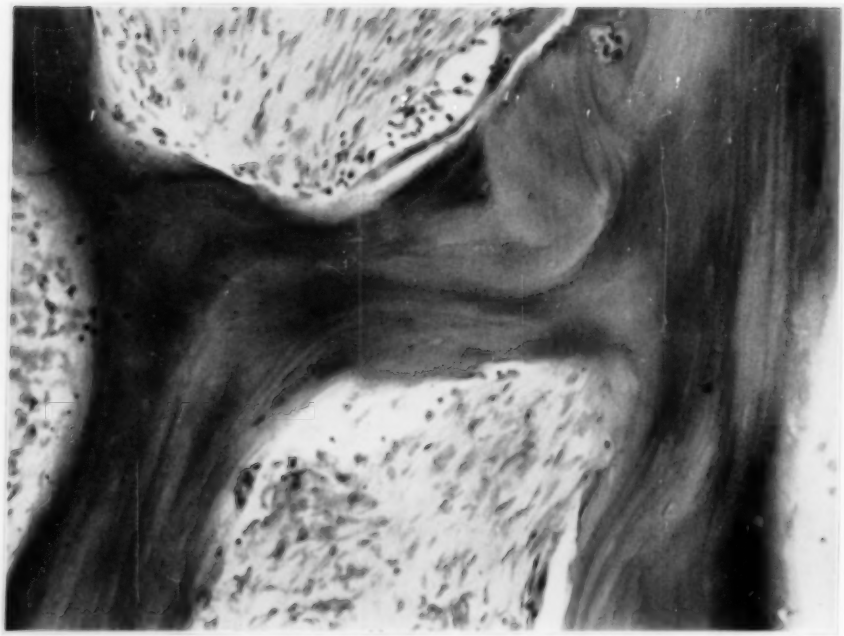

FIG. 2-B

FIG. 2-A

Fig. 2-A: Frozen homogenous bone (× 55) three weeks after implantation into muscle. There is no evidence of any osteoblastic activity. There is invasion of the cortical and cancellous portions of the graft by a dense fibrous tissue. Fresh homogenous and frozen autogenous bone is similar in appearance.

Fig. 2-B: Frozen homogenous bone (× 225) three weeks after implantation into muscle. There is absence of osteogenesis along the margins of the trabeculae.

Wilson [28] in 1951 on air-preserved bone suggests that the healing of bone-bank grafts takes place by a process of invasion, absorption, and replacement similar to that of fresh autogenous bone grafts. Wilson stated that fresh autogenous bone grafts and bank-bone grafts were indistinguishable several months after implantation, despite the more rapid incorporation of fresh autogenous grafts into the host bone. He believed that any

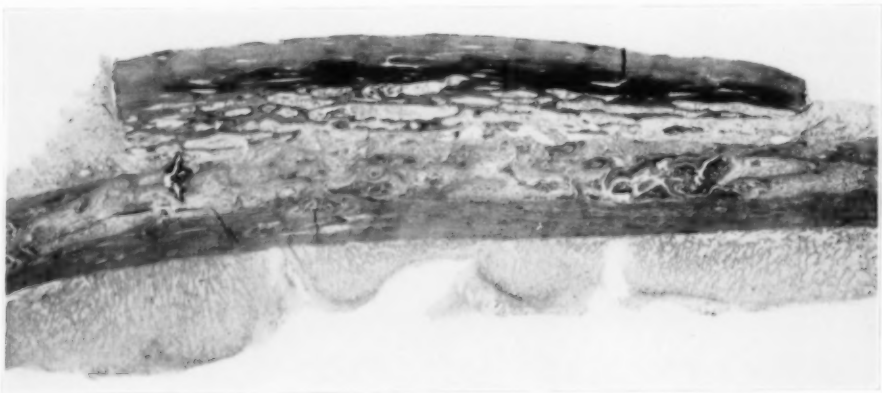

FIG. 3-A

Os purum graft (× 6). Two weeks after application to host rib the graft is firmly attached. The pattern of invasion of viable tissue into the os purum scaffolding resembles that found in all grafts except fresh autogenous bone grafts.

FIG. 3-B

Os purum graft (× 18) two weeks after transplantation. Dense fibrous tissue has penetrated into the cancellous bone. Newly formed osteoid seams attach the graft to the host bed. [Reproduced from *Surgical Forum*, p. 426 (Proceedings of the Forum Sessions, Thirty-seventh Clinical Congress of the American College of Surgeons, San Francisco, California, November, 1951), Philadelphia, 1952, by permission of W. B. Saunders Co.]

FIG. 3-C

Os purum graft (× 130) two weeks after transplantation. There is extensive absorption of os purum by osteoclasts and fibrous tissue. Living bone trabeculae form along the margins of the cancellous os purum. There is infiltration by lymphocytes and plasma cells.

This rapid growth of osteogenic tissue from the host bed has made microscopic interpretation difficult, especially when the bone matrix is not clearly differentiated by staining, as it was in this case.

difference was clinically insignificant. The experimental work of these authors was basically in agreement with the work of Barth [3] who had stated in 1893 that all elements of transplanted bone die and are replaced by newly formed bone arising from the host bed. In 1908 Barth [4] admitted that fresh autogenous bone grafts were capable of active new-bone formation, but maintained that from a practical point of view, for the filling of bone defects in the skull and long bones, necrotic bone chips or bone dust was equally effective. This viewpoint is at variance with the work of Axhausen in 1908, Phemister in 1914, Mayer and Wehner in 1914, Gallie and Robertson [10] in 1920, and Haas [12] in 1922; the latter believed that, in fresh autogenous bone grafts, osteogenetic properties persist and that this plays a significant part in the incorporation of the graft into the host. Abbott and his co-workers in 1947 confirmed this view and evaluated the osteogenetic properties in fresh cancellous and cortical autogenous bone grafts.

EXPERIMENTAL PROCEDURE

1. *Choice of the Graft Bed*

In this experiment, the host osteogenic bed upon which a graft was to rest in perfect coaptation was prepared by removing the periosteum and the outer margin of the cortex from the host rib. This graft bed was so situated that the graft could be firmly immobilized on it. It was capable of good vascular supply and osteogenetic response. Controls of such a prepared osteogenic bed were removed at intervals of two and four weeks for histological examination. By use of this onlay-graft technique, the invasion of osteogenetic elements into the graft arose entirely from one surface and the histological examination was therefore simplified.

2. *Choice of Bone for Grafts*

A uniform pattern for comparative purposes at the time of histological examination

FIG. 4-A

Fig. 4-A: Fresh homogenous graft (× 6). At two weeks, the graft is firmly fixed to the host bed. [Reproduced from *Surgical Forum*, p. 426 (Proceedings of the Forum Sessions, Thirty-seventh Clinical Congress of the American College of Surgeons, San Francisco, California, November, 1951), Philadelphia, 1952, by permission of W. B. Saunders Co.]

Fig. 4-B: Fresh homogenous graft (× 55) two weeks after transplantation. Newly formed trabeculae extend from the cortex of the host rib to the trabeculae of the under surface of the cancellous portion of the graft.

Fibrous tissue and moderate round-cell infiltration extend upward under the cortical portion of the graft.

FIG. 4-B

was obtained by use of split-rib grafts of uniform length. These were used as onlay grafts and firmly held on the host osteogenic bed by two stainless-steel wires or fine silk sutures. The cancellous intramedullary portion of the graft rested on the prepared bed. The cortical margin of the rib was of value in showing the rapidity of the remodeling of the graft after its incorporation into the host bone.

Ninety specimens of fresh autogenous and homogenous, air-preserved frozen autogenous and homogenous, boiled homogenous, and os purum grafts were used; they were removed at intervals of two, four, and eight weeks.

All frozen specimens were air-preserved at −30 degrees centigrade under sterile conditions. The os purum was prepared from split ribs of dog skeletons, acetone, potassium hydroxide, and concentrated salt solution being used.

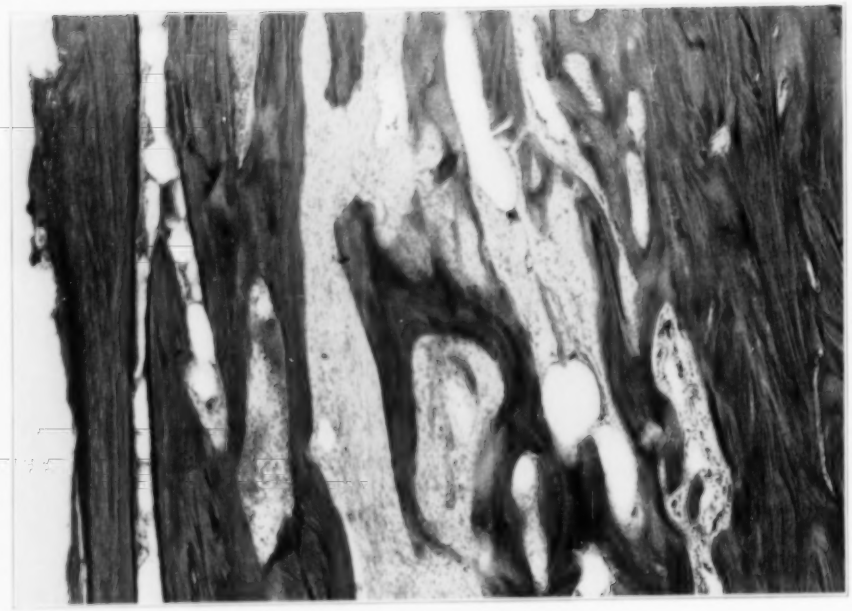

FIG. 6

Boiled homogeneous graft (× 47.5) two weeks after transplantation. The pattern of invasion and replacement is similar to that seen in Figs. 4-B and 5.

FIG. 5

Frozen homogeneous graft (× 47.5) two weeks after transplantation. The pattern of invasion and replacement is similar to that seen in Fig. 4-B.

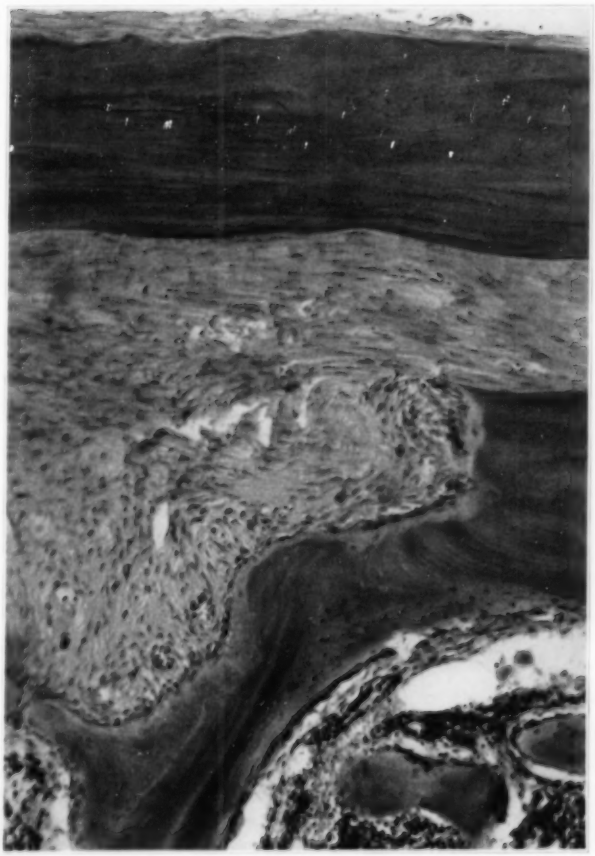

Fig. 7: Frozen autogenous graft (× 125) four weeks after transplantation. In all grafts except fresh autogenous, dense fibrous tissue persisted in some areas. In this specimen, the deep surface of the cortex is separated from the cancellous portion by dense fibrous tissue. The authors consider this to be the reaction of living tissue to a relatively inert foreign body.

3. *Choice of Controls*

Each type of graft was also studied under conditions providing good circulation and immobilization but without osteogenetic response from the host. In this experiment, thirty-eight specimens, including fresh autogenous, fresh homogenous, air-preserved frozen homogenous, and boiled homogenous bone were implanted into the paravertebral muscles of the low back and were removed at intervals of two, three, four, and eight weeks. This method of determining viability and osteogenesis was effectively utilized by Axhausen, Phemister, Gallie and Robertson [9, 10], and Haas [13–15].

FIG. 7

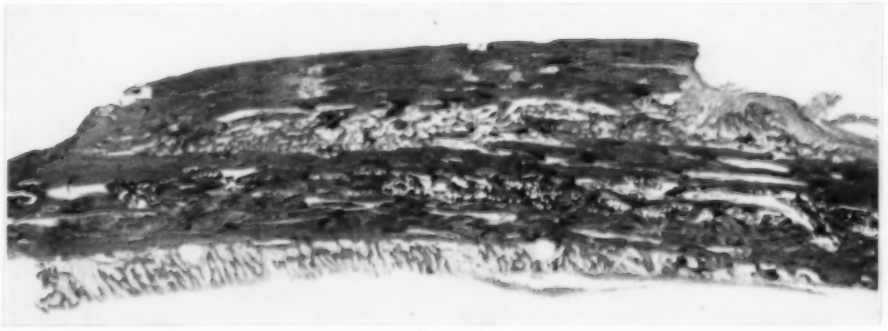

FIG. 8-A

Fig. 8-A: Fresh autogenous graft (× 8) two weeks after transplantation. The graft is firmly united to the host bed.

Fig. 8-B: Fresh autogenous graft (× 125) two weeks after implantation. The end of the graft shows osteogenetic activity throughout. Neighboring Haversian systems show extensive creeping replacement. No other type of bone used in this experiment illustrated similar osteogenesis at this stage. There is less infiltration of fibrous tissue and inflammatory cells than in other types of graft material at this stage.

Fig. 8-C: Fresh autogenous graft (× 500) two weeks after transplantation. There is osteogenetic activity along the outer margins of the cortex. Although this was found in some areas, it was not considered as significant as the response from cancellous trabeculae.

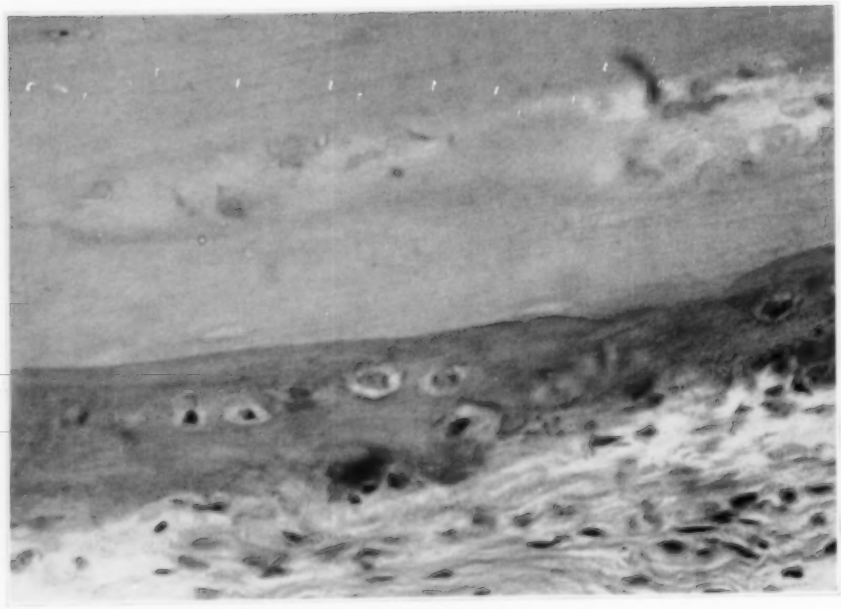

FIG. 8-C

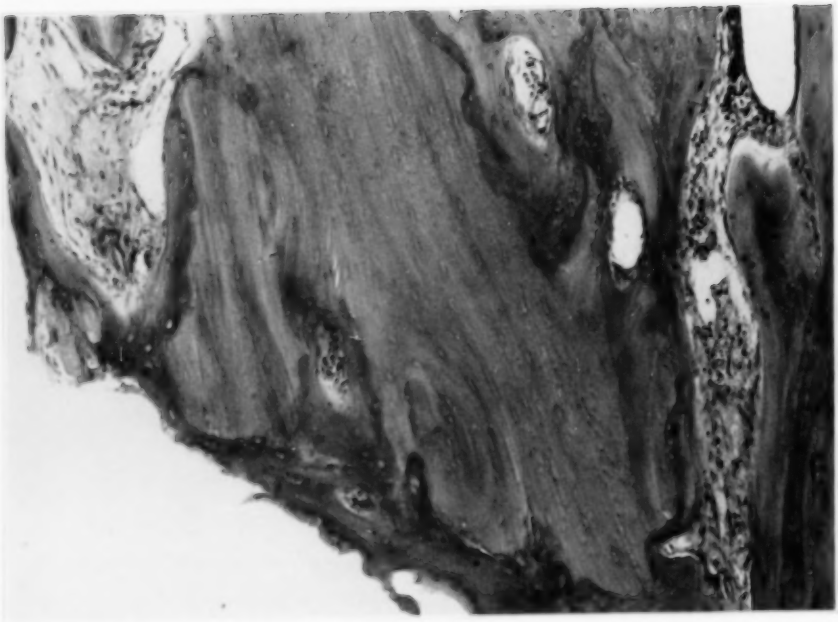

FIG. 8-B

FIG. 9

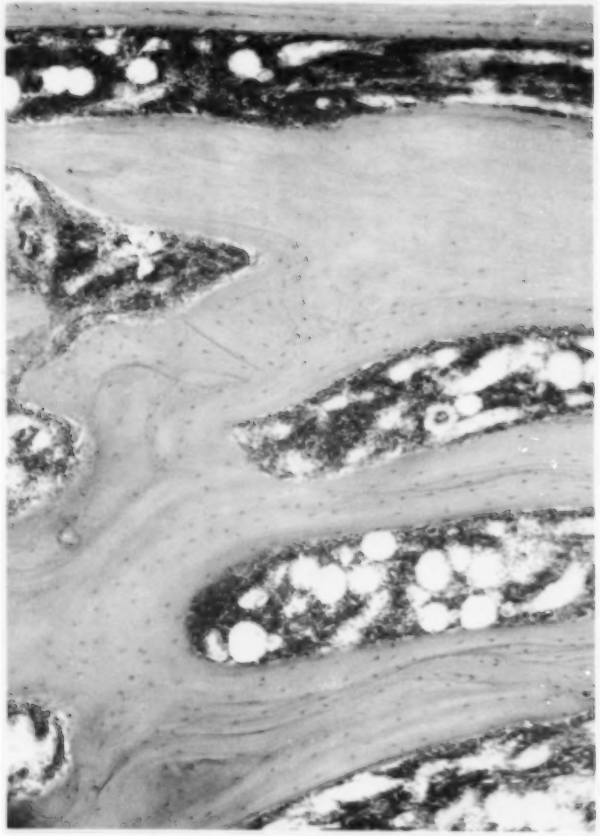

FIG. 10

Fig. 9: Homogenous fresh graft (× 175) eight weeks after transplantation. Creeping absorption is still a dominant factor even at eight weeks in non-viable grafts.

Fig. 10: Fresh autogenous graft (× 100) eight weeks after transplantation. Hematogenous marrow is present in all Haversian systems. Viable osteocytes line the margins. There is no evidence of any reaction to the graft by the host tissue. Incorporation of the graft is considered completed.

4. *Preparation of Specimens for Histological Study*

Specimens implanted into muscle were removed in such a manner as to preserve the soft tissue about the graft, which would aid in its evaluation on longitudinal section. All specimens used as bone grafts were removed along with the entire host bed. Specimens were fixed in formalin and were decalcified and sectioned longitudinally, celloidin technique being used.

RESULTS

Histological examination of the bone specimens implanted into muscle revealed that:

1. Osteogenesis was present only in the fresh autogenous bone grafts.

2. The surface area which showed osteogenesis in the fresh autogenous graft was minimal along the cortical surface and maximal along the endosteal surface of a split-rib graft.

3. A dense layer of fibrous tissue and osteoclasts characteristic of a foreign-body reaction was noted in the fresh homogenous, air-preserved frozen homogenous, and boiled-bone implants.

Histological examination of the onlay bone grafts showed the following:

1. There was union of the cancellous portion of all grafts to the host osteogenic bed in the specimens removed at two weeks.

2. The pattern of growth of bone from the host osteogenic bed into the cancellous portion of the graft was similar in all grafts used.

3. In this process of creeping substitution the phase of replacement was more prominent in fresh autogenous grafts, whereas the phase of absorption often predominated in the preserved and boiled-bone grafts.

4. Evidence of osteogenesis in the area of the cortex and Haversian systems two weeks after transplantation was noted only in the fresh autogenous grafts.

5. A foreign-body reaction consisting of dense fibrous tissue was noted between the graft and invading osteogenic tissue from the host in all grafts of preserved bone and in the fresh homogenous grafts.

SUMMARY

In this experiment, 141 split-rib grafts implanted into mature dogs showed the following:

1. All grafts were successfully transplanted in that they were incorporated into the host osteogenic bed.

2. Histological examination revealed osteogenic cells and osteocytes to survive only in fresh autogenous bone grafts. This osteogenetic activity was found to take part in the incorporation of the graft into the host tissue.

3. Fresh autogenous bone grafts were more readily tolerated by the host tissue than the preserved bone grafts or fresh homogenous grafts.

NOTE: The authors are indebted to Dr. C. H. Hatcher and the late Dr. D. B. Phemister of the University of Chicago Clinics and to Dr. E. Campbell of the Albany Medical College for their aid and encouragement.

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DISCUSSION

Dr. Robert D. Ray, Seattle, Washington: Dr. Bosworth and his associates are certainly to be highly commended for their well controlled clinical study, as are Dr. Campbell and his co-workers for their timely experiments. Both groups have concluded that fresh autogenous bone grafts are superior to other types of bone-grafting materials. However, many of those here today also attended the recent meeting of the American College of Surgeons in San Francisco, where another group of investigators reported on a series of similar experiments from which they drew conclusions diametrically opposed to those just presented. Granting the accuracy of the observations and the validity of the conclusions, there must be an answer to this apparent paradox and it would appear to lie buried in four fundamental and as yet unanswered problems.

The first problem deals with the cellular elements present in the grafts. Can they survive transplantation and, if so, do they survive in numbers sufficient to influence the ultimate fate of the graft? On the basis of experimental evidence now available, the first part of this compound question can be answered in the affirmative—at least some of the cells of fresh autogenous bone can survive in ectopic sites. There is also evidence suggesting that the cells of embryonic limb-bud anlage and of fracture callus can survive freezing or lyophyliz-

ing for limited periods and will subsequently proliferate if transplanted. Apparently the more highly differentiated cells of mature cancellous and cortical bone do not survive under such circumstances. The answer to the second part of the question—do the cellular elements survive in significant numbers—may depend on the thickness of the graft (since survival of the cells is dependent on diffusion of tissue fluids through the graft), on the density of the graft (whether it is cortical or cancellous), and on the vascularity of the recipient site. These suggestions are based partly on experimental evidence, partly on supposition. Further experimental work will be necessary before definitive answers can be given.

The second problem concerns the fate of the organic matrix of the graft in the process of replacement. If the collagen or mucopolysaccharide of the graft is incorporated in the newly deposited bone, frozen grafts should be superior to deproteinized grafting materials. If, on the other hand, the host develops an immune reaction to the foreign protein of homogenous grafts, the reverse may prove to be true. The latter possibility is being investigated in several laboratories at the present time.

The third problem involves the inorganic apatite crystals of the graft. Are these incorporated in the new bone as the graft is replaced? Positive statements to this effect have been made, although experimental proof is lacking.

The fourth problem, perhaps the most fundamental of all, concerns the host and the factors involved in metaplasia of the local cells. What is responsible for the rapid cellular proliferation and differentiation of the skeleton following trauma? What causes ectopic ossification in such varying sites as surgical scars, atheromatous plaques, and caseous tubercles? Is it the result of many interrelated biochemical factors, such as hydrogen-ion concentration, carbon dioxide tension, local increases in histamine, calcium, phosphate, or enzyme concentrations; or can ectopic ossification be "induced" by a specific chemical organizer?

When these four problems have been solved, it should be possible to approach the subject of bone replacement on a rational rather than an empirical or pragmatic basis and to explain the apparent discrepancies in many of our clinical and experimental observations.

I should like to express my hope that both groups of authors will continue their clinical and experimental studies.

Dr. Fred C. Reynolds, St. Louis, Missouri: One of the fundamental questions concerning bone transplants has always been: Do some of the cells of an autogenous graft survive and, if so, are they capable of instigating the process of fixation and replacement of the grafts so as to influence materially the outcome, or is the process of fixation and replacement of an autogenous graft entirely due to the response of the host bone? Dr. Campbell's experimental work closely resembles previous studies in the fate of transplanted bone and his interpretation of these results tends to show that a sufficient number of osteogenetic cells survive that transplantation.

On the other hand, from a similar type of experiment we concluded that a significant number of cells did not survive and that the process of fixation and replacement of the graft is entirely the function of the host bone. It is impossible by studying fixed microscopic slides to tell the sources of the cells you see lining bone grafts. We have observed at the end of three weeks a layer of apparently pliable osteoblasts along the surface of a known dead graft. We have not had the experience of having a layer of fibrous tissue interposed between the host bed and graft. There is no question that the major portion of any autogenous graft dies and has to be replaced. There is no question at all that a preserved graft is necrotic and has to be replaced by the host tissues.

Since the process of fixation and replacement of a known dead graft and an autogenous graft is essentially the same so far as we can tell, it seems obvious that some other factors besides the survival of some of the cells are important in determining the end result of the transplant. Mosiman [b] has shown that when bone grafts are transplanted into the anterior chamber of the eye, only autogenous bone will grow, and Haas [a] had demonstrated that, when fractured bone is transplanted into muscle, only autogenous bone will show evidence of healing. There seems little question, therefore, in view of these various experimental studies, that some osteogenetic cells do survive autogenous transplantation. Whether or not this fact alone can explain the difference found with the clinical use of preserved bone remains to be established.

Clinical experience to us at least has shown that autogenous bone grafts are superior to homogenous bone grafts under all circumstances and we feel that bank-bone grafts should be restricted to carefully selected cases. Concerning Dr. Bosworth's paper I wish to state that our experience in using bank grafts for spine fusions of all kinds has been essentially the same, in that we reported failure in 36 per cent. of the cases, as compared with his failure in 32.7 per cent. His findings, I think, are even more significant than ours, since the prolonged immobilization usually necessary for the treatment of tuberculosis would increase the number of cases of union with bank grafts; it is well known that such grafts need prolonged immobiliza-

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tion. I do not believe that we can anticipate better than 70 per cent. of success in using preserved bone even under the most favorable circumstances. We have entirely discontinued the use of bank bone in spine fusions except in those cases in which there is no available supply of autogenous bone or in the rare case when it is felt that the taking of the graft may materially influence the condition of the patient. We have not had any experience with hemifusions, but I do not believe that a hemifusion in the spine can be expected to be as satisfactory as a bilateral fusion.

Dr. C. Howard Hatcher, Chicago, Illinois: In these two papers Dr. Bosworth's clinical observations correlate well with the experimental findings of Dr. Campbell. The argument as to whether any elements of a bone graft survive and take part in its repair is an old one. Barth in 1893 in the study of transplanted bone at first concluded that all elements die and that the repair or replacement comes only from the host. One year later that author reversed his opinion and admitted that osteogenetic elements of the graft do survive, proliferate, and take part in creeping replacement. The discussion went back and forth for many years, to be pointed up in recent years by the popularity of bone banks. Unfortunately, observation upon clinically used bone from a bank offers little opportunity for accurate interpretation. Most of the bank-bone grafts have been used as space-occupying bone or in instances where they provided an acceptable apparatus for rigidity. Only rarely have opportunities been offered for observation of the behavior of bank bone of any sort when real stress is placed upon that graft, either early or late, such as in the repair of a defect following massive resection. It is yet to be shown that bank bone is equal to fresh autogenous bone under such conditions. I think that neither of the authors would say that bank bone should never be used. Certainly, it does have a place in filling out cavities or perhaps as an internal bone splint.

I am discussing this paper in the place of Dr. Phemister and it is fitting that I remark that in 1914 Dr. Phemister made his first major contribution to bone and joint surgery. The title of this paper was "The Fate of Transplanted Bone and Regenerative Power of Its Various Constituents".[b] The conclusions reached by Dr. Phemister in 1914 are well substantiated by the work presented today. Thirty-seven years later, after a career in which he made many contributions to bone and joint surgery, Dr. Phemister was again engaged upon the experimental investigation of grafts of various types applied to massive defects in the skeleton. That work is as yet incomplete, but the indications of the work, so far as he was able to carry it, are that bank bone does not suffice for transplantation to a skeletal part upon which marked stress will be placed.

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Dr. Philip D. Wilson, New York, N. Y.: I requested permission to discuss both of these papers because of the work we have done with the Bone Bank at the Hospital for Special Surgery from 1946 to the present. I recently reported [b] a follow-up of operative procedures with the use of bank bone in 248 patients with successful results in 85 per cent.

I should like first to say a few words about the experimental work of Dr. Campbell and his colleagues and then to discuss Dr. Bosworth's paper. Dr. Campbell has shown us some beautiful sections of different types of onlay grafts on ribs and I do not dispute the conclusions he has drawn from study of these slides. The only point I would like to make is that he is using an experimental set-up in which there is contact all along the surface between the graft and the host bone; this does not permit accurate differentiation of the healing of the different types of grafted bone. I believe that a better test is obtained by a segmental resection of a portion of a dog's fibula and a replacement by a graft of whatever type of bone is to be studied. In this kind of experiment only the ends of the graft are in contact with the host bone and little or no osteogenetic activity may be expected of the fibrous or muscle tissues which touch the longitudinal surfaces.

We have reported one series of experiments [b] of this kind and a report on a second series is in press [d]. [Illustrative slides in support of the discussor's statements were shown. These showed the healing of autogenous grafts to be similar at the end of two weeks, in favor of the autogenous at the end of four weeks, and again about the same at the end of six weeks. At the end of fourteen to sixteen weeks dogs with refrigerated transplants had even better results than those with autogenous grafts.]

At the same time we ran a series of experiments in which transplants of autogenous, refrigerated, and boiled bone, each with a partial fracture made by a saw cut, were put in the back muscles of the dog. These were removed at different periods after transplantation and studied. In none did we obtain healing of the saw cuts, but we did find evidence of new-bone formation in each of the three types of bone.

I think all this goes to show that there is still much about the healing of bone grafts which we do not understand and that the experimental evidence should be analyzed carefully before we draw conclusions.

About Dr. Bosworth's paper: I think he has been led astray by making each intervertebral space a criterion of success or failure of his fusion. I question whether a small group of operative cases can be accurately evaluated in this way or whether the conclusions he has drawn can be considered valid. It is of little interest

to a patient whether he has one or several levels of pseudarthrosis; what really matters is that he has to have another operation. Also I believe that when healing is delayed at one level, it is apt to be retarded at several levels and factors other than the type of graft used may play a part in this delay.

We are in the process of making a survey of the results of fusion for Pott's disease at the Veterans Hospital, Kingsbridge Road, New York City. Thus far, we have compiled the results in 106 operations about equally divided with regard to the use of autogenous and refrigerated homogenous bone transplants. In the series, as far as operative procedures are concerned, the bank bone was more successful than the autogenous bone. When the results are computed on the basis of the number of fusion intervals, the number of failures is higher with bank bone than with autogenous bone. The outstanding conclusion from the patient's point of view is that there are too many failures from both methods. The failures of fusion in Pott's disease are much higher than in other conditions, such as scoliosis, in which we are dealing with normal bone. Perhaps we are wrong in trying to draw too many inferences from operative failures in that disease.

Finally, I would like to quote what Sir Reginald Watson-Jones said when speaking of bone-grafting at the American College of Surgeons meeting in San Francisco last year. In substance he said that, if he had to perform a bone-grafting operation, he wanted grafts the bone cells of which would fight for him. That is a good statement. Whenever I have to bridge a gap with a bone graft, I prefer to use an autogenous graft. The advantage one gains is probably not greater than 10 per cent. over a bone-bank graft, but one wants to give the patient the greatest chance of success. In other circumstances, refrigerated bone has so many advantages from the standpoint of availability, reduction in operating time, and saving the patient additional operative procedures that we certainly should not condemn it without more evidence than has yet been produced.

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Dr. Bosworth (closing): I do not say that bone-bank bone will not grow or that it should never be used. I do point out to you that it is not as effective as autogenous bone. We have presented some facts and as time goes on further facts will declare themselves in a way that will reveal the proper rationale for the use of bank bone. These studies are, I believe, valuable.

The comparison of hemifusions with bilateral fusions in these tuberculous patients was made on a statistical basis. If all bone grafts are used on one side, and if the patient is recumbent for a long time, as is the case in a tuberculous patient, the situation is different from that of a hemifusion performed on a patient in whom stresses are greater and who is allowed ambulation earlier, as is the case in a scoliotic patient.

Dr. Campbell (closing): Much as I appreciate the excellent clinical work of Dr. Wilson and his coworkers, I am not in agreement with their interpretation of microscopic sections from bone implants in the experimental animal, which they have published in the past. However, in the slide which Dr. Wilson has shown there was union at both ends of the graft. That is all that was demonstrable to me at this time in this slide.

We feel that in bone-graft work the host osteogenic bed should be made as simple as possible, so that osteogenetic elements within the graft itself, the growth of bone from the bed into the graft, and the reaction of the host tissues to the graft may be evaluated.

These points were amply illustrated, I feel, in the slides shown.

MANIPULATION OF THE SPINE *

BY EDWARD G. EWER, M.D., OAKLAND, CALIFORNIA

The subject of manipulation of the spine periodically becomes the focus of great interest and enthusiasm among orthopaedic surgeons. It is in such a phase that we now find ourselves. Twenty-five years ago we were over-zealous in the use of manipulation of the spine, especially as concerns the methods of manipulation under anaesthesia which were advocated by Bankart. This is not to say that manipulative surgery should be completely condemned. The value of manipulative procedures in the treatment of back disorders is well established. At times the discussion which follows may appear paradoxical. It is intended as a plea for the careful, judicious use of this form of treatment in carefully selected cases. On the other hand, it is a denunciation of indiscriminate manipulation applied before an adequate diagnosis has been made and of its use in instances where it is unsuitable or unsafe. There are orthopaedists who recently have stated that 100 per cent. of ruptured intervertebral discs are cured in their hands by manipulation alone. Statements of this type must be challenged. We should not lose all sense of values and become merely manipulators. In other words, manipulation of the spine should assume its proper place only as another adjunct in our treatment of back disorders.

Some orthopaedic surgeons look upon manipulation of the spine as a form of pseudo-medicine bordering on quackery. Nothing can be further from the truth. The basis for this conclusion undoubtedly lies in the fact that cults on the fringes of sound medical practice base their dogma on various manipulative procedures. Sir Robert Jones in 1932 said, "It is sufficient to say we should mend our ways rather than abuse the unqualified. Dramatic successes at their hands should cause us to inquire as to the reasons: it is not wise or dignified to waste time in denouncing their many mistakes, for we cannot hide the fact that their successes are our failures, and that it is only by adding to our knowledge and perfecting our technique that we can hope to banish the bone-setter from our midst."

The purpose of this paper is to present generally acceptable methods of manipulation of the spine and also to point out possible dangers. The literature on this subject has become voluminous in the last twenty-five years. Many authors are radical in their approach to this problem. The majority, fortunately, lean to the conservative side. Few references are made to manipulation of the spine other than to manipulation in the lumbar and sacroiliac regions. There are, however, many patients who complain of discomfort in the neck and upper part of the back, and many of them can be helped by manipulation of the cervical and thoracic portions of the spine.

The author feels that manipulation, contrary to the general belief, does not cure. Careful analysis of this statement will prove it to be true, except in some forms of trauma. What, then, do we accomplish by manipulation? The unorthodox say the dislocation was reduced or the vertebrae were put back into place. Roentgenographic evidence rarely justifies this statement. However, the work of Knutsson in 1944 paved the way to explain why manipulation may be beneficial. He showed that, with intervertebral-disc degeneration and narrowing of the interspace, there is a forward and backward slipping of the bodies of the contiguous vertebrae. When this abnormal motion occurs, the apophyseal joint relationship is altered. It is, therefore, not inconceivable that the joint facets may become locked from a minor twist or strain. The locking and altered relationship of the superior and inferior articular facets may be so slight that roentgenographic evidence is inconclusive. Proper manipulation does relieve many patients who are in acute distress and does so promptly and dramatically, but it does not in any sense effect a permanent cure. A cure

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 30, 1952.

FIG. 1

FIG. 2

FIG. 3

Fig. 1: Position assumed for massage and stretching of the cervical spine.
Figs. 2 and 3: Positions assumed for manipulation of cervical spine.

should mean complete and continued relief. The underlying primary cause of the distress, such as poor body mechanics, congenital defects and abnormalities, arthritic joint changes, neurogenic diseases, and muscle imbalance, must be alleviated before a cure is possible. Our duty, then, is first to make a correct diagnosis; second to bring relief; and last to make the relief permanent.

The author is of the opinion that manipulation of the spine in whatever form is not without danger. For this reason it has been his practice to avoid manipulation under anaesthesia, if possible, and to confine this form of treatment to an office procedure. Jostes [3] put it very succinctly: "The conscious patient is a very efficient check on the amount of force necessary, and the patient often supplies a ready signal to let the operator know when the reduction as such has been accomplished or relief comes". If a single manipulative procedure effects the desired result, it is unnecessary to run the gamut of manipulative exercises as is done under anaesthesia. Force is necessary with or without anaesthesia, and the possibility of paralysis is ever present. Most neurosurgeons have probably seen cases of paralysis caused by manipulative procedures.

Manipulation of the spine should be used primarily on the young and vigorous. Injudicious manipulation of an osteoporotic spine can be catastrophic, the results being far more disabling than the original complaint. This method of treatment is obviously contra-

FIG. 4

FIG. 6

FIG. 5

Fig. 4: Position of patient and surgeon for manipulation of mid-thoracic region.
Fig. 5: Alternate method for manipulation of mid-thoracic region.
Fig. 6: Method of manipulation of high thoracic area.

indicated in the presence of fractures, bone tumors, rheumatoid arthritis, pyogenic infections, and the granulomata; and yet it has been used in these conditions. A spinal-cord tumor or an extruded nucleus pulposus cannot be cured and is seldom alleviated by manipulation; and yet all too frequently the attempt is made. The successes are achieved in the degenerated intervertebral discs with narrowing of the interspace, but not in the presence of intraspinal space-consuming lesions.

Application of too great a force may result in fracture of any of the component parts of the vertebra. Consequently, care in the performance of the manipulation must be exercised. Judgment of the proper leverage and force and a knowledge of the range of motion come with experience.

To safeguard the patient from injury as a result of manipulation, an adequate history should be obtained. This, with the proper physical examination, will rule out the previously mentioned contra-indications. Adequate roentgenograms should always be obtained if there is any doubt of pathological bone changes.

This paper will not be confined to the treatment of the low-back region alone. The neck and thoracic areas will be discussed first. In any orthopaedic practice, patients present themselves with the complaint of pain in the neck. These patients fall mainly into two groups: those who have received some form of trauma and those whose complaint is chronic in nature. Patients in the latter group usually show hypertrophic arthritic changes, or

Fig. 7

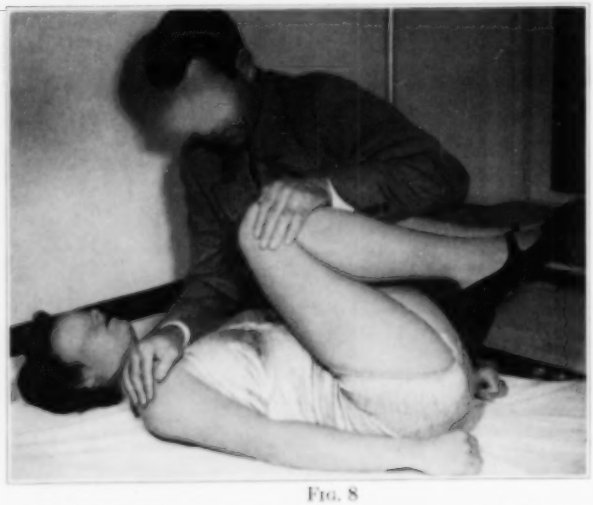

Fig. 8

Fig. 7: Method of applying sudden traction to leg for low-back manipulation.

Fig. 8: Forceful flexion of thighs on abdomen for lumbar manipulation.

they may have a low-grade focal infection.

In cases of trauma the injury may be minor. A slight twist or jerk of the head may have been sufficient to cause the injury. More severe sprains, such as are caused by rear-end collisions—the so-called "whipped neck" is one of these—are acutely painful. The pain may be confined to the neck, or it may be accompanied by radiation to the head, shoulders, and arms. In many instances the cervical spine is not only splinted by muscle spasm, but apparently may be locked in one or more directions.

Stretching and manipulation of the neck by the use of Sayre traction can be most beneficial. If these patients are seen early, before myositis or fibrositis has occurred, recovery is far more prompt. The method usually employed by the author is as follows (Figs. 1, 2, and 3): The Sayre head sling is applied while the patient is seated. Approximately thirty to forty pounds of traction is applied. Gentle massage of the posterior cervical muscles for thirty to sixty seconds will greatly reduce the spasm. The operator, standing behind the patient, places his left hand on the left side of the patient's chin and holds the right shoulder firmly. The patient is encouraged to turn his head to the right as far as possible and the operator gently but firmly forces rotation another few degrees. The rotation manipulation is then reversed. Usually audible clicks occur, but they are not always essential to relief. The patient is then instructed to apply hot compresses and to hold the head and neck in correct posture. This manipulation is performed three to five times a week. Complete relief can usually be expected in ten days. Many are relieved after the first manipulation.

Patients in the second group, with arthritic spines and infectious myositis, are also benefited by the above procedure. However, their recovery may be prolonged. While stretching and manipulations are being carried on, postural exercises should be ordered. Faulty postural habits while the patient is at work, reading, driving a car, or at bed rest, should be corrected. A search for any focus of infection should also not be overlooked.

The thoracic area of the spine is also subject to sudden acute episodes of pain. The pain may be confined to any level directly over the vertebrae or it may radiate, following the course of a single intercostal nerve. In the latter case, the origin of pain is probably in the articulation of the rib. Some of these patients are in such acute distress that they are completely disabled. Some even have been put to bed with the diagnosis of coronary heart disease.

FIG. 9

Adduction pelvic rotation for manipulation of low-back and sacroiliac joints.

A simple method of manipulation which the writer has found to be efficacious is as follows (Fig. 4): With the patient standing, the operator locks his arms around the patient's chest; the patient is told to take a deep breath, exhale, and relax. The operator then forcibly compresses the rib cage, at the same time slightly lifting the patient and hyperextending the thoracic area. Occasionally two or three attempts may have to be made, the operator changing the level of his arms slightly each time.

Pain localized in the central and paravertebral thoracic area can best be relieved by the following method (Fig. 5): The patient is placed prone on a firm table. The operator stands on a footstool and places his palms over the painful area of the back. The patient is then told to exhale and relax. Not until the surgeon feels sure that the patient is relaxed should he apply a sudden forceful downward thrust. This should also be performed at two or three different levels.

The upper three or four thoracic vertebrae cannot be satisfactorily manipulated by the above method. Figure 6 demonstrates how manipulation in this area can be accomplished. The patient stands with his hands clasped behind his head. The surgeon stands behind him and passes his arms under those of the patient, clasping his hands at the back of the patient's neck. The patient is then advised to lean slightly backward and relax. The surgeon then lifts and forces the neck forward with a gentle motion until there is a sharp snap.

Manipulation alone, as has been stated, by no means completes the cure. Postural rehabilitation is necessary, and instruction should be given on avoiding mechanical stresses and strains beyond the patient's capacity. Other routine orthopaedic treatment should also be used, including braces and supports when indicated.

In most types of manipulation, the usual audible and palpable clicks occur. Although these are not necessary, it has been the author's experience that relief is obtained more often with their occurrence than without. Except in occasional instances, the author does not wholeheartedly subscribe to the theory of subluxations. He does believe that apophyseal joints may become locked with resultant ligamentous oedema and muscle spasm, followed by subjective pain. Some argue that the palpable click is only of psychological benefit.

We now come to the more familiar and controversial area of low-back manipulation. The theories concerning causes of low-back pain are legion. It is not within the scope of this paper to discuss them all. This discussion will be limited to the traumatic conditions

with low-back pain occurring from major and minor sprains from whatever cause; the author believes that herein lies the largest field for manipulative relief.

Patients with these conditions must be divided into two groups: those with and those without sciatica. True sciatica implies nerve-root irritation and is usually found to follow a definite neurological pattern, depending upon the nerve root involved. The pain and hypalgesia usually extend into the foot. False sciatica, on the other hand, is a generalized radiation over the buttocks and posterior aspect of the thigh, and does not usually extend below the knee.

In patients with low-back pain and true sciatica, ruptured intervertebral discs or cord tumors may be suspected. Before manipulation is attempted, these conditions should be ruled out, for manipulation in these cases cannot effect a permanent cure and offers great hazards.

The other group, in which the cause of pain lies in the lumbar apophyseal and sacro-iliac joints, is more amenable to manipulation. According to neuro-anatomical studies, this type of radiation pain is through the sympathetic reflex arc. Manipulation of these patients can best be safely carried out as follows (Fig. 7): The patient is placed supine on a firm immovable table. As in other manipulations, relaxation is to be desired. The operator stands at the foot of the table and the extended extremity on the painful side is grasped with both hands about the ankle. A sudden forceful jerk is applied. The other extremity is then treated in the same manner. In many instances the patient experiences dramatic relief, and no further manipulation is necessary. If no relief is experienced, the next manoeuvre is performed. This consists in forcefully flexing both flexed limbs on the abdomen a few times (Fig. 8). The last manoeuvre, which is particularly effective in sacro-iliac strains, is as follows (Fig. 9): The patient is supine. The extremity on the affected side is flexed at a right angle and adducted over the opposite side. The ankle is placed on the opposite knee. The shoulder on the same side is held flat against the table. When relaxation is as complete as possible, a sudden downward thrust is applied to the flexed thigh. The same manipulation is performed on the opposite side if necessary.

Following the manipulation, the back is strapped with adhesive tape and the patient is advised to apply heat and rest. Rarely in the author's experience has repeated manipulation on successive days been of value. If success was not achieved the first time, later attempts have also been failures.

CONCLUSIONS

1. Manipulation of the spine in the presence of intraspinal space-consuming lesions and certain other pathological conditions is contra-indicated and hazardous.

2. Manipulation under anaesthesia is more dangerous and does not compensate for the risks involved.

3. No originality is claimed for the simple, relatively safe methods presented, which in the author's experience have been effective.

4. As orthopaedic surgeons, we cannot overlook a method of treatment which in selected cases offers our patients so much relief.

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DISCUSSION

Dr. C. Leslie Mitchell, Detroit, Michigan: Dr. Ewer has brought to our attention a very timely and controversial subject. Unquestionably, any procedure, such as manipulation for back disorders, which has withstood the test of time cannot be completely overlooked and must be given careful consideration. The injudicious use of these procedures by the unscrupulous, the untrained, and the inexperienced has from time to time brought disrepute to the method, as has been the case with fundamentally sound procedures for other conditions. The medical profession has been reluctant in the past to adopt the indiscriminate use of manipulation for back disorders because of the many dire results which have been seen and, because its members are a group of rational men, they have hesitated to undertake a procedure for a condition the etiology of which was so poorly understood. Orthopaedists and neurosurgeons, with their improved knowledge of anatomy, physiology, and pathology as related to back disorders, are now in a position to make better and earlier diagnoses, and accordingly to select those cases which would be suitable and safe for manipulative procedures.

Dr. Ewer has stressed the careful selection of cases and has mentioned the number of contra-indications. I am in accord with the essayist in his plea that this procedure shall be reserved for the acute case, that it should not be done under anaesthesia, and that it should not be carried out in the presence of an intraspinal space-consuming lesion. The importance of a careful study of the history and careful physical examination cannot be overemphasized. I would like also to stress that roentgenograms should always be taken before any manipulative procedure is attempted. I am pleased that Dr. Ewer emphasized that manipulation is not a cure and that further remedial measures are always indicated.

Traction as a method of treatment for painful lesions of the cervical spine is now well accepted, and the result in the acute cases is almost uniformly good. The etiology is not always clearly understood, but the muscle spasm which results is most effectively relieved. This is best accomplished by means of halter traction; in my experience further manipulation is rarely indicated. Certainly, manipulation is not indicated for cervical-disc herniation with nerve-root irritation.

I have had very little experience with manipulation for painful lesions of the thoracic spine. Sudden onset of acute pain in the thoracic spine has been fairly uncommon in my experience and, when present, has usually responded satisfactorily to bed rest, physical therapy, and occasionally novocain injections. Manipulations of acute low-back disorders in selected cases, by the method outlined by Dr. Ewer, will often prove successful in relieving the patient's acute distress. Certainly we have all had the experience during a routine examination with straight-leg raising that the patient suddenly exclaims that he feels completely relieved of his symptoms and gets up from the examining table with perfect ease. I prefer, however, that the patient who is considered a suitable candidate for manipulation be given preliminary heat and massage of the back and frequently a mild sedative. The manipulation should be done gently, and, as stressed by Dr. Ewer, repeated procedures are to be condemned if the patient does not obtain relief the first time.

I agree with Dr. Ewer that elderly patients, those with chronic symptoms, and those with typical sciatic radiation of pain should not be subjected to manipulation.

The cause of these sudden, acutely painful attacks in the back is still not clearly understood; nor do we have an entirely satisfactory explanation as to why some of them obtain dramatic relief from manipulation. I am inclined to agree with Keegan and others who feel that many of these cases represent pathological changes in the disc, with a defect in the annulus fibrosus and posterior longitudinal ligament, but without a complete herniation. It cannot be disputed that most patients who present the typical picture of disc herniation with sciatic distribution of pain give a history of having had repeated episodes of low-back pain previously, but without sciatic pain, which have often been dramatically relieved previously by manipulation. To quote Dr. Keegan[a], "The sensation of sudden slipping which occurs in so many backs, often brought on by insignificant stooping strain and followed by varying disability, seems to necessitate some freely movable structure in the back which shifts position at these times. It is difficult to conceive that movement between the articular processes causes this sudden pain, but it is rather easy to understand that a loose nucleus pulposus, which shifts position within the annulus fibrosus of the disc, could cause the pain."

I would like to compliment Dr. Ewer for his careful presentation of this difficult subject, in which he has outlined the indications for the procedure and has emphasized its limitations and the pitfalls that accompany its indiscriminate use.

a. Keegan, J. J.: Neurosurgical Interpretation of Dermatome Hypalgesia with Herniation of the Lumbar Intervertebral Disc. J. Bone and Joint Surg., **26**: 243, Apr. 1944.

Dr. Mather Cleveland, New York, N. Y.: I am grateful to Dr. Ewer for at least two new wrestling holds. There are actually a limited number of manoeuvres which can be used on the spine, and he has demonstrated most of these,—that is, traction, compression, flexion, extension, rotation, and lateral bends. He has done well to emphasize the fact that each of these manoeuvres done with violence or great force can be disastrous.

Dr. Ewer has very wisely emphasized that manipulation of the unconscious patient is dangerous, and that all that is accomplished is relief of symptoms but not cure. However, I think that we should bear in mind that at least two cults and probably more have thrived and are still thriving on manipulation of the

spine. It is true that irregular practitioners have an occasional disaster. At the same time they must help a great many patients—I know they do. If the patient is relieved of his pain, he is not so likely to question whether or not the manipulator knows what he is doing.

I have used most of the manoeuvres described by Dr. Ewer, and some of them are of very great value. Traction on the cervical spine carefully applied has its place, as has rotation of the low back. I am not a believer in the sacro-iliac joint manipulation.

Forcible hyperextension of the thoracic spine, if it is really forcible, could conceivably cause a disc protrusion.

I think we should bear in mind the possibilities of relief by means of manipulation of the spine as well as the limitations of manipulation; again, a diagnosis should in every case be established if at all possible. In other words, to manipulate a spine without having all the facts at your disposal and without roentgenograms is far too hazardous.

The Need for Basic Investigation in Orthopaedic Surgery

(*Continued from page 288*)

tive men from many segments of our population to advise with us concerning ways in which orthopaedic surgery as a specialty may best attain its objectives and serve the public. Such an affiliated lay council would be composed of outstanding men from the professions of law and engineering, the fields of education, labor, finance, and others. I can envisage such a group as a powerful stimulus toward putting several chairs of orthopaedic surgery on a firm foundation and thus furthering basic investigation. Although such a non-medical lay affiliate is a unique departure in a medical society, it is common practice in the support of hospitals and other organizations serving the public. Its seeming unorthodoxy is not a matter for concern. I would urge, therefore, that the work of the Committee for the Advancement of Orthopaedic Surgery be encouraged and financed and that it be authorized to develop such a lay affiliate to help further the objectives of this Academy. I would also urge that this Committee be charged with the responsibility for an early attack on the problem of stimulating basic research in orthopaedic surgery. For this Committee to continue with its brilliantly started work will take time and further appreciable financing before anything tangible can be expected to eventuate. I believe any investment the Academy many make in furthering the work of the Committee for the Advancement of Orthopaedic Surgery will be returned to you with compound interest.

My few personal thoughts may have a tone of dissonance. They should not. I am proud of the accomplishments of the specialty of orthopaedic surgery over the past twenty-five years, but I am also eager that its future achievements may reach new horizons. Although the main theme of this discourse, "The Great Need for Basic Investigation in Orthopaedic Surgery", has been developed along the line of my own personal thinking, I know from conversations with many of you that it is not an original observation. The need for basic investigation in orthopaedic surgery is a subject about which a great many of you are concerned, and this is one of the reasons I have chosen to speak about it. There may be much disagreement with the ideas I have expressed for altering this trend, and I am certain there are many better ideas for correcting it in the minds of many people who have patiently listened to me.

The privilege of serving as your President has been a humbling and enriching experience. It has been a year of association with a group of men ever anxious to do their best for this society, with no motives of personal aggrandizement. Such an experience will always remain a warm and satisfying memory.

PROBLEMS OF POSTOPERATIVE POSITION AND MOTION IN SURGERY OF THE HAND *

BY JULIAN M. BRUNER, M.D., DES MOINES, IOWA

A proper postoperative position and a sound schedule of postoperative motion may make all the difference between success or failure in surgery of the hand. On completion of a tendon or nerve repair or a skin plastic operation in the forearm or hand, the surgeon is confronted with the following questions:

1. What position is required to relax the repaired structures at the suture line, and how long should this position be maintained?

2. How long is it safe to maintain this position without damage to joints and stiffening of the hand?

3. If a single finger tendon has been repaired, how much motion, if any, is permissible in the uninvolved fingers and thumb?

4. How soon should voluntary active movement in the injured finger be started, and how much movement should be allowed?

The answers to these questions may be more or less obvious to the surgeon who frequently treats hand injuries, but they are perplexing to many who are called upon to do so only occasionally. Indeed, some of these problems are at present unsettled. However, certain basic questions demand tentative answers at least, until final answers are forthcoming.

The purpose of this paper is to assemble and integrate specific, detailed information relative to postoperative position and motion after tendon and nerve repair in the forearm and hand. This information is not readily available at present from any single source. Fractures will not be included in this discussion, although the same basic principles also apply to them.

THE PROBLEM OF POSITION

Three basic positions of the hand are commonly used in postoperative immobilization—namely, the position of function, the position of flexion, and the position of extension. Before discussing these, it is well to consider the so-called position of rest.

Position of Rest

A classic description of this position was given by Wood Jones:

"To determine the position of rest we must do as Ellis did, and watch the part when relaxed in sleep, when nerve control is temporarily in abeyance and when the real 'postural tone' of the muscles alone is exerting itself. Then we shall see that the forearm is held somewhat pronated, that the wrist is flexed, the palm of the hand hollowed, and the digits bent in towards the palm in varying degree. The little finger is most bent . . . Annularis shows the next degree of flexion . . . Medius is not quite so acutely flexed . . . The index finger is flexed to a distinctly lesser degree . . . The thumb is held midway between flexion and extension, and it is slightly adducted and opposed . . ."

Position of Function **

The position of function takes into account the dynamics of the hand and wrist during useful work; it is described by Bunnell [3] as follows:

"The hand at rest assumes a certain position. This is largely the mid-position of the range of motion of each and every joint, including the wrist, and rotation of the forearm. The muscles are all nicely balanced so that at their normal tone when at rest the position called the position of function is assumed. . . . The forearm is half-way between pronation and supination. The wrist is in about 20° of dorsiflexion and 10° of ulnar

* Presented at the Annual Meeting of the American Society for Surgery of the Hand, Chicago, Illinois, January 26, 1952.

** The term "position of function" was used in 1925 by Kanavel, who emphasized its importance in connection with the treatment of infections of the hand.

flexion. The fingers are slightly flexed in each of their joints, the index being flexed least and the little finger most. The thumb is forward from the hand in partial opposition and its joints are also partially flexed."

In order to understand the relation of the position of rest to the position of function, it is necessary to appreciate the reciprocal relationship of the wrist joint to the joints of the fingers and thumb, which is created by the constant length of the tendons in both flexor and extensor groups. Under conditions of complete muscle relaxation, flexion of the wrist causes extension of the digits, and extension of the wrist causes their flexion. Expressed in another way, this means that the degree of flexion of the wrist is inversely proportional to the degree of flexion of the digits when muscle tone is at a minimum. This principle of automatic action is utilized in tenodesis operations.

From the strictly anatomical standpoint, since the range of volar flexion of the normal wrist joint exceeds the range of dorsiflexion, the wrist joint, considered by itself, is in mid-position, or the position of rest in slight flexion. The relaxed hand is thereby opened up and the digits are straightened to a position of only slight flexion. The wrist joint "calls the tune" in regard to the position of the digital joints. On the other hand, if the wrist is placed in 20 degrees of dorsiflexion, the hand is thereby almost closed, and flexion of the finger joints (especially of the metacarpophalangeal and proximal interphalangeal joints) approaches 90 degrees.

From the practical standpoint, therefore, it is mandatory for protracted immobilization that the wrist be placed in moderate dorsiflexion in order to protect and preserve the prehensile function of the hand. But the hand must also be opened up somewhat from the completely relaxed position, so that the digital joints assume a position of mid-flexion. The position of function is therefore a compromise position dictated by two practical considerations: first, that this is the most useful position of the hand for most of its functions (such as grasping or pinching) and second, that, if some stiffness of joints occurs in this pose, a useful range of joint motion will still be available.

The "sick" hand, if allowed to remain unsplinted, usually gravitates into the position of rest with flexed wrist and relatively extended fingers. It is disastrous to leave the hand in this position for any protracted period; this is what splinting in the position of function avoids.

The position of function is dwelt upon because in spite of its extreme importance we often give it only lip service. A common fault in its application is failure to place the metacarpophalangeal joints in flexion—surely a cardinal sin. The metacarpophalangeal joint is to the finger what the hip joint is to the lower extremity. It is the key joint. The tendency of the metacarpophalangeal joints to stiffen in extension, because of contracture of the collateral ligaments and joint capsule, is well known; this condition is very disabling. This deformity, with inability to touch the finger tip to the palm, is difficult to correct fully by any known means, a fact recently emphasized by Littler.

Other faults seen in hands supposedly splinted in the position of function are: adduction of the thumb, which should be in opposition, and radial flexion of the wrist, which should instead be in 10 degrees of ulnar deviation, as well as in 20 degrees of extension. One reason for faulty position is the rather widespread use of ready-made splints which do not fit the individual hand. Every hand deserves a "tailor-made" splint whether of metal or plaster.

The position of function is usually indicated in the treatment of burns, infections, after skin plastics and after some open (compound) injuries. In cases of severe trauma it is essential to splint the hand at once, otherwise oedema and stiffness may make it virtually impossible to force the hand into a favorable position.

Position of Flexion

The position of flexion is the second basic position used in surgery of the hand. It is required after suture, transfer, or graft of flexor tendons of the fingers, thumb, and wrist.

FIG. 1

FIG. 2

Fig. 1: *Position of function:* 20 degrees of dorsiflexion and 10 degrees of ulnar flexion of the wrist; moderate flexion of all digital joints and opposition of the thumb.

Indications: after skin plastics, certain open injuries, burns, and infections of the hand.

Fig. 2: *Incorrect position:* illustrating the two most common faults: failure to place the metacarpophalangeal joints in semiflexion and the thumb in opposition.

FIG. 3

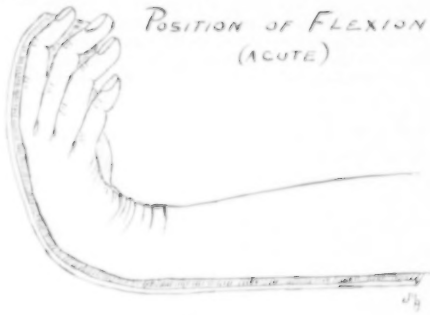

FIG. 4

Fig. 3: *Position of flexion (moderate):* about 45 degrees of flexion of the wrist joint, with all digits allowed to assume their relaxed reciprocal positions (moderate flexion).

Indications: after most primary repairs of the flexor tendons of fingers, thumb, or wrist, at any level, and of the median or ulnar nerve in the forearm.

Fig. 4: *Position of flexion (acute):* flexion of the wrist joint approaching 90 degrees. This is a potentially dangerous position to the wrist if it is continued for long.

Indications: this position may be necessary after secondary suture of flexor tendons and nerves in the forearm.

Its purpose is to relieve tension at the suture line of tendons; this tension may be caused by muscle tone, by shortening from atrophy of disuse of muscle and tendon in delayed cases, or by actual loss of length from trauma; in median-nerve and ulnar-nerve suture in the forearm it is also necessary to make possible apposition of the nerve ends.

If the wrist is placed in moderate flexion and the hand is allowed to open up reciprocally, this may be considered a position of rest, and this is the correct position. The fingers and thumb should not be forced into additional flexion, for this places the extensor tendons in a position of strain. The position of flexion is a non-functional position in regard to the wrist joint, dictated by necessity and justifiable for only short periods of time.

Unfortunately, in delayed or late suture of the median and ulnar nerves in the forearm, loss of nerve length consequent to resection of neuromata often makes it necessary to place the wrist in acute flexion in order to accomplish nerve suture, and this position must be maintained to prevent separation of the sutured nerve ends. In such cases, the acutely bent position of the wrist should be eased as soon as it is safe to do so. If there has been too much loss of length in a nerve, or if prospect of return of nerve function is doubtful, we believe that the risk of damage to joints from prolonged splinting may outweigh anything to be gained by a "long-shot" nerve suture. Loss of nerve function should be accepted and joints should be kept mobile.

CASE 1. A man, aged twenty-seven, had had both median and ulnar nerves in the forearm severed from a glass cut four months before admission. Following the original nerve repair, the forearm had been splinted

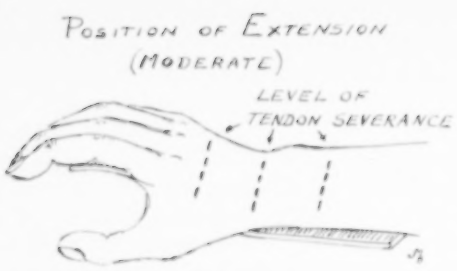

FIG. 5

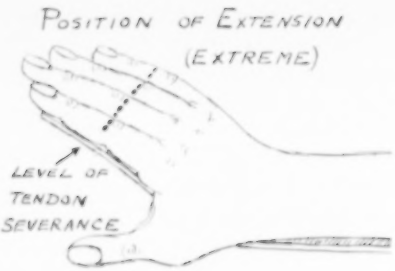

FIG. 6

Fig. 5: *Position of extension (moderate)*: 20 degrees of dorsiflexion of the wrist, 175 degrees of extension of metacarpophalangeal joints, flexion of interphalangeal joints (20 to 30 degrees).

Indications: after suture of extensor tendons of fingers at any level proximal to the metacarpophalangeal joints; after repair of extensor tendons of the wrist; after suture of radial nerve. (Moderate extension and abduction of the thumb is also required after radial-nerve suture.)

Fig. 6: *Position of extension (extreme)*: 20 degrees of dorsiflexion of the wrist, 175 degrees of extension of the metacarpophalangeal and interphalangeal joints. This is a potentially dangerous position to the finger joints if continued long. Return of flexion range of fingers is very slow.

Indications: only after suture of the extensor tendons on dorsum of fingers (except in distal segment).

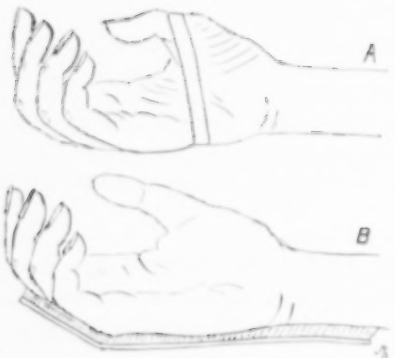

FIG. 7

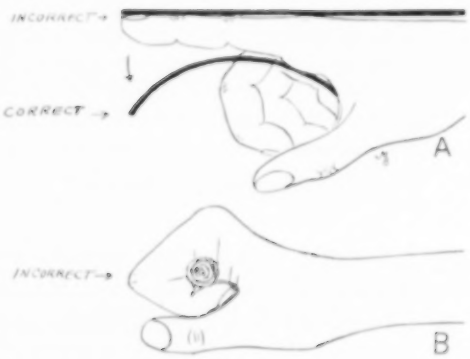

FIG. 8

Fig. 7: *A*. After suture of the median nerve, a position of moderate opposition is indicated to prevent overstretching of the thenar muscles during the long period of nerve regeneration.

B. After ulnar-nerve suture, splinting is indicated to prevent hyperextension of the metacarpophalangeal joints and clawing of the fourth and fifth fingers.

Fig. 8: *A*. "Tongue-depressor" splinting of the finger in full extension after minor injuries is a common but dangerous practice. The position is non-functional. If splinting is indicated, an aluminum strip should be used, bent to the desired curvature.

B. "Roller-bandage" splinting of the hand after flexor-tendon repair may result in a stiff hand with flexion contracture of the fingers.

with the wrist in sharp flexion for many weeks. He entered the hospital because of open sores on the hand, resulting from trauma during the convalescent period.

When first seen by us, he had trophic ulcers on the index finger and thumb with complete loss of function of both ulnar and median nerves. His range of wrist-joint dorsiflexion was completely lost, because of joint stiffness and contracture of flexor muscles in the forearm. After amputation of a portion of his index finger and thumb because of osteomyelitis, complete healing was obtained, but weeks of splinting and physical therapy to regain wrist extension were of no avail. Loss of dorsiflexion range in this patient was permanent.

Moderate wrist flexion (about 45 degrees) is all that is usually required after primary suture of flexor tendons of the fingers. After suture of the flexor pollicis longus, even less wrist flexion is required, since relaxation of this tendon is aided by adduction of the thumb, as well as semiflexion of the metacarpophalangeal and interphalangeal joints.

After tendon repair some mobilization of the wrist joint is generally begun at about the same time that active motion of the fingers is instituted (twenty-one days). We have never experienced any difficulty in regaining a full range of dorsiflexion of the wrist joint after restraint of the wrist in moderate flexion for this period.

Position of Extension

The position of extension is the third basic position used in surgery of the hand. It is indicated after suture, transfer, or graft of the extensor tendons of the fingers, thumb, and wrist, and after suture of the radial or dorsal interosseous nerve.

It is agreed that the wrist should be in moderate dorsiflexion (about 20 degrees). It is also agreed that the metacarpophalangeal joints of those fingers in which extensor tendons have been repaired should be placed in almost full extension. This is unfortunate for reasons already mentioned, but, unless it is done, full extension range of the finger will not be restored by tendon repair.

Great care must be used, however, never to splint the metacarpophalangeal joints in hyperextension; this is a vicious position for the joint capsule and full flexion range may never be regained. About 5 degrees of flexion of the metacarpophalangeal joints is the optimum position.

There has been, however, some difference of opinion concerning the proper position of the interphalangeal joints. Formerly these joints were often placed in full extension. With the wrist and metacarpophalangeal joints also in extension, this is an exceedingly strained position and one which renders the fingers almost useless in the event of stiffness.

CASE 2. A man, aged thirty, was referred for examination because of inability to close his fist. The extensor tendon to his middle finger on the back of the hand had been severed one year previously. The single extensor tendon had been sutured and the wrist and all fingers had been splinted in full extension for five weeks.

Examination showed normal action of the sutured tendon, but the range of all finger joints, especially of the metacarpophalangeal joints, was limited in regard to flexion. Although he had had extensive physical therapy and had been back at work for nine months, he could not touch his palm with any of his finger tips. Loss of the ability to close the hand was permanent.

It is now considered safer practice, after extensor-tendon suture proximal to the metacarpophalangeal joints (on the dorsum of the hand or forearm), to put both the proximal and the distal interphalangeal joints in moderate flexion (20 to 30 degrees). In this way, two of the three joints in each finger are placed in a more functional position and the ability to regain full flexion range is expedited. The end results after splinting in this position are good, and restoration of the full extension range of the finger may be expected.

The usual practice after extensor-tendon repair on the back of the hand, wrist, or forearm is to splint the entire hand, exclusive of the thumb, with all of the fingers in the above position—that is, 5 degrees of flexion at the metacarpophalangeal joints and 20 to 30 degrees of flexion at the interphalangeal joints—and then at one of the early changes of dressing to take some of the uninvolved fingers out of the splint. However, it is possible to accomplish differential placement of the uninvolved fingers immediately after repair, the metacarpophalangeal joints of these fingers being placed in greater flexion than the metacarpophalangeal joints of the involved fingers. This is the method we have used, the advantage being that all sound fingers are placed at once in a more functional position.

For example, if the extensor tendon to the index finger has been sutured on the back of the hand, the index finger is supported individually on a volar wire loop incorporated into the volar plaster forearm splint, with its metacarpophalangeal joint in almost full extension (175 degrees), and the interphalangeal joints in moderate flexion (20 to 30 degrees). It is kept at rest in this position for three weeks, in order that firm union may take place at the suture line. The middle finger is allowed a position of moderate flexion at all joints, being supported in its proximal segment by the edge of the volar plaster splint, and it is allowed restricted motion in all joints. The ring and little fingers are allowed almost complete freedom as regards both position and motion.

Severance of an extensor tendon on the dorsum of the finger itself, or buttonhole rupture of the central slip at the proximal interphalangeal joint, obviously requires splinting of the proximal interphalangeal joint as well as the metacarpophalangeal joint of the af-

fected finger in extension. A slightly flexed position is permissible at the distal joint. Under these conditions differential placement of the remaining fingers in flexion becomes more difficult, and is especially limited when the ring finger is the injured one. However, it is important to place every sound finger in slight flexion at each joint if this is consistent with anatomical possibilities and the comfort of the patient.

Rupture of the extensor tendon at the distal joint or avulsion of the tendon at its insertion requires specific corrective positioning. Bunnell [3] advises hyperextension at the distal joint, with 60 degrees of flexion at the proximal interphalangeal joint, "to allow the two lateral bands of the extensor aponeurosis to shift volarward", this position to be maintained for six weeks by plaster.

There is, however, some difference of opinion as regards splinting for this

FIG. 9-A

FIG. 9-B

FIG. 9-C

Fig. 9-A: Mrs. M. M., aged thirty-three. Photograph shows individual support of ring finger after extensor-tendon suture on dorsum of the hand. The metacarpophalangeal joint is in 175 degrees of extension, the interphalangeal joints in 20 to 30 degrees of flexion. This permits differential placement of the uninvolved fingers in greater flexion and allows some independent motion of these fingers.

Figs. 9-B and 9-C: Showing restoration of full extension and flexion range of the ring finger six weeks after injury. Swelling of the hand had disappeared, allowing patient to replace her rings.

FIG. 10-A

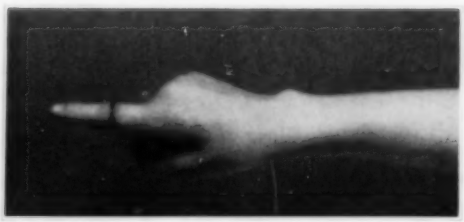

FIG. 10-B

FIG. 10-C

Fig. 10-A: G. R., boy, aged nine. Photograph shows individual support of index finger after repair of extensor tendon over the proximal interphalangeal joint; all three slips had been severed. The metacarpophalangeal joint was splinted at 175 degrees, the proximal interphalangeal joint at 175 degrees, and the distal interphalangeal joint at 160 degrees. The uninvolved fingers were permitted a position of slight flexion at all joints and were moved actively from the first.

Figs. 10-B and 10-C: Full range of motion in index finger was restored eight weeks after injury. Oedema had disappeared.

injury. Mason splints the hand with the wrist joint in moderate extension, the metacarpophalangeal joint of the involved finger in very slight flexion (5 degrees), and both interphalangeal joints in extension for two to three weeks; he then changes to a splint of the Lewin type on the finger only for an additional period of two to three weeks.

After surgery on the extensor pollicis longus tendon, the thumb should be splinted in abduction and extension, great care being taken to avoid strain and hyperextension of joints. After repair of the short extensor or the long abductor of the thumb, joint freedom appropriate to the action of the repaired tendon is indicated.

After all extensor-tendon surgery, protective splinting at night is essential for as long as six weeks, in order to prevent harmful fist-clenching motions which may occur during sleep. If this is neglected, extreme flexion of the digit may cause the suture line to give way partially or completely, and failure to regain full extension range may result.

Elevation of the Hand

The problem of position also includes the position of the upper extremity in relation to the body. Elevation of the hand on a pillow should be routine during the first few days after surgery, and when the patient is out of bed he should wear a sling. In crushing injuries, elevation of the hand considerably above the level of the body by suspension of the splint from an overhead frame is of great value in preventing oedema. Care must be taken that there is no constriction of the hand, wrist, or forearm. In later stages, very short periods of dependency al-

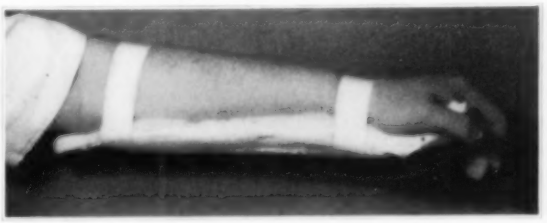

FIG. 11

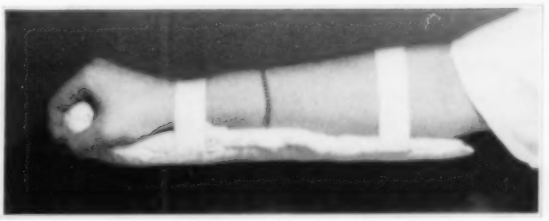

FIG. 12

FIG. 13

FIG. 14

Fig. 11: Splint for position of function with motion of fingers and thumb permitted: a volar plaster slab, ending at the level of the proximal palmar crease.

Fig. 12: Splint for position of function with support of fingers and thumb: a volar plaster slab with a plaster roll incorporated into one end of the slab and molded to fit the hand.

Fig. 13: Splint for position of extension of the thumb, used after suture of the long extensor tendon: a padded volar plaster splint, holding the thumb in extension and abduction, and permitting free motion of all finger joints.

Fig. 14: Dorsal hand splint, made of aluminum, for use after resection of the palmar fascia for Dupuytren's contracture, allowing active motion of all digital joints except the metacarpophalangeal joints of the affected fingers, in order to prevent motion at suture line of the palmar incision.

ternating with long periods of elevation will assist the return of circulation and will minimize oedema and stiffness.

Splints for the Basic Hand Positions

For the position of function, we have found an anterior padded plaster-of-Paris splint to be most useful. If motion of the digits is desired, the plaster slab should end at the level of the proximal palmar crease. If the digits are to be immobilized, a small roll of plaster is incorporated into one end of the slab. It is molded into a mass about the size and shape of a lemon which fits into the palm and supports the digits in semiflexion and the thumb in opposition.

The sheet metal "derby-hat" splint designed by Allen and Mason is also very useful in maintaining a good functional position after certain open injuries of the hand and in those cases where moist dressings are indicated.

After skin plastics or resection of palmar fascia for Dupuytren's contracture or similar conditions, the individual fixation of fingers may be required. For this purpose a sheet-metal splint cut to the shape of the hand and fingers is invaluable in maintaining a modified position of function.

For the position of flexion, a posterior (dorsal) padded plaster splint is most satisfactory. In children this should be extended above the elbow, to keep the hand from pulling back into the splint.

For the position of extension an anterior (volar) padded plaster splint is used, with extensions to support the involved fingers or thumb, made of stout wire loops which are incorporated into the plaster.

Special Positions after Nerve Suture

After nerve suture, in addition to the restraining splint to prevent tension at the suture line, special splinting is indicated to prevent over-stretching of paralyzed muscles and tendons. Such splints are applied after the initial restraining splint has been removed. They are worn during the long period of nerve regeneration; during this interval the patient is encouraged to use his hand with the paralyzed muscles thus protected.

Ulnar Nerve: During regeneration of the ulnar nerve the metacarpophalangeal joints should be splinted in slight flexion to prevent hyperextension and clawing of the ring and little fingers. This is best accomplished by the use of a posterior padded aluminum splint for the forearm and hand, extending to the level of the proximal interphalangeal joints (this should be made in the brace shop). A flange alongside the thumb prevents stretching of the paralyzed adductor muscle.

Median Nerve: After median-nerve suture, the thumb should be partially rotated to face the fingers, in order to prevent strain on the paralyzed thenar muscles. This may be effected by the use of a single leather loop attached to a wristlet to keep the thumb in moderate opposition.

Radial Nerve: During regeneration of the radial or dorsal interosseous nerve, the wrist, fingers, and thumb should be supported in moderate extension by a splint which allows the patient to use the hand actively, but prevents stretching of the extensor-supinator group of muscles and tendons in the forearm. Splints of the Oppenheimer or Thomas types are most useful for this purpose.

THE PROBLEM OF MOTION

Although temporary immobilization of the hand is essential for the healing of repaired structures, it must be admitted that such immobilization for any length of time and in any position is abnormal and leads to some degree of stiffness which may be temporary or permanent. The human hand is in a state of almost constant motion from birth onward, even during sleep. Immobility is not natural to it and the hand reacts unfavorably.

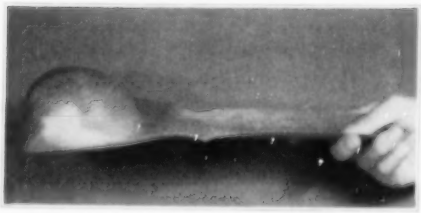

FIG. 15-A

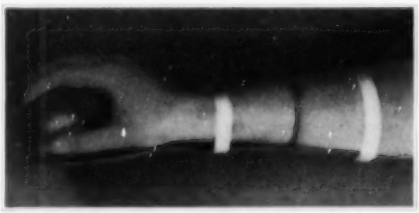

FIG. 15-B

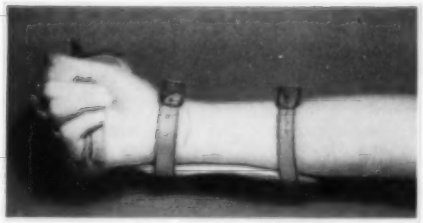

FIG. 16-A

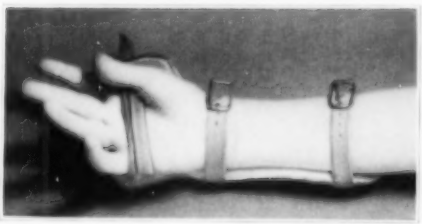

FIG. 16-B

Figs. 15-A and 15-B: "Derby-hat" splint, after Allen and Mason, made of sheet aluminum and used to maintain position of function.

Figs. 16-A and 16-B: Leather-covered sheet metal splint used after suture of the ulnar nerve. This splint helps to prevent clawing of the fingers. A flange next to the thumb keeps the thumb in adduction (see Fig. 7-B).

Assuming the integrity of the bony framework of the hand and of the muscles and motor nerves, the problem of motion is one of tendons and joints. Considering first the tendon factor, two questions naturally arise: (1) How soon and to what degree is tendon motion desirable after suture? (2) How soon and to what extent may uninjured fingers be moved?

Tendon Motion

Mason and Allen, in their experimental study on the rate of tendon healing, found two chief causes of failure after tendon suture: adhesions between the tendon and surrounding tissues and the formation of a bulbous enlargement at the site of tendon juncture. They found that these undesirable effects were minimized by a sustained initial period of rest and were aggravated by early motion. In clinical practice they keep sutured tendons completely immobilized for three weeks. Bunnell also advises complete rest of the sutured tendon for three weeks.

In discussing Boyes' paper on Flexor-Tendon Grafts in the Fingers and Thumb in 1950, Bunnell suggested gentle, active motion during the first week after tendon grafting. Pulvertaft, who has had much experience with tendon grafts, begins careful motions of small amplitude on the second or third postoperative day.

Although it must be admitted that there are some differences in gliding problems after tendon suture and tendon graft, it is obvious that complete rest of the sutured or grafted tendon for three weeks is safest from the standpoint of firm union at the suture line. As to adhesions, the burden of proof would seem to be on those who advocate early motion. Experimental work and clinical observation indicate that, if a tendon becomes fixed by adhesions, this is probably not due to a lack of early motion, but to other factors. Other points may influence the surgeon in choosing the precise time to start motion, such as the method of tendon suture, the material used, the age of the patient, and the degree of his cooperation.

It is generally agreed that, during the fourth, fifth, and sixth weeks after tendon surgery, active motion of the finger in which the tendon has been repaired should be gradu-

ally increased both in amplitude and vigor. Warm soaks and special exercises without the splint may be undertaken after careful instruction of the patient.

Normal full activity of the hand is usually not attempted until after six weeks. About this time it is also usually safe to discard the restraining splint in cases of tendon repair; but, if either of the large nerves in the forearm has been sutured, an even longer period of restraint may be advisable to safeguard the integrity of the neurorrhaphy. In this matter no general rules are possible.

Movement in Uninvolved Digits

The question of movement in uninvolved digits is anatomical and may be summarized as follows:

1. After suture of the extensor tendons of the thumb, or of the long abductor, free active movement of all fingers is indicated.

2. After suture of the long flexor tendon of the thumb, motion of the fingers is desirable, but it is noted that the thumb, restrained in adduction, stands somewhat in the way of free finger flexion. Even such restricted movements of the fingers, however, are useful in preventing stiffness.

3. After suture of a single finger flexor tendon, free motion of the thumb is permissible. Motion in the fingers in which the tendons are intact is limited, however, because of the interdigitations of the profundus flexor tendons, only the tendon to the index finger being separate. Moreover, the third and fourth lumbrical muscles usually take origin from adjacent sides of the profundus tendons to the long, ring, and fifth fingers, thus sharply limiting independent action in these three fingers. The fingers are like four horses in harness, abreast. The individual members of the "four-in-hand" are quite restricted by their anatomical harness; of the four, the index is the freest, the ring finger the most restricted.

It is estimated that the independent excursion of the profundus flexor tendons is as follows: index, one inch; medius, one-half inch; annularis, one-quarter inch; minimus, one-quarter inch. Independent motion of uninvolved fingers after flexor-tendon repair is therefore impractical, except in the case of the index finger, where a little motion may be permissible after tendon repair in the other three. Usually, however, after suture of a single finger flexor tendon, all fingers are kept at rest for three weeks.

4. After suture of a solitary finger extensor tendon, the thumb should have free motion. Independent motion of uninvolved fingers is restricted in those fingers adjacent to the injured one by the junctura tendinum, which loosely unite the extensor tendons on the dorsum of the hand.

The usual arrangement of these diagonal bands is that they converge distally upon the extensor tendon of the middle finger and diverge distally from the extensor tendon of the ring finger, thus providing the middle finger with a "check rein", the ring finger with a "martingale". The index and minimus, being peripheral, receive only one band from adjacent tendons.

If the index finger is held out straight (180 degrees at all three joints) it is not difficult to flex the other three fingers at all three joints (the pointing position of the hand). However, if any of the other fingers is held in full extension individually, the remaining three fingers are flexed with difficulty; this restricting effect is usually most marked when the ring finger is the one held straight.

This phenomenon is better demonstrated when the hand is put in the "intrinsic-plus" position (90 degrees of flexion of metacarpophalangeal joints and 180 degrees of extension of interphalangeal joints). From this position it is virtually impossible for most persons to extend the ring finger individually—a handicap well known to musicians.

The limitation of independent motion of the individual fingers in various positions is a composite effect resulting from the anatomical restrictions imposed by, first, the interdigitations of the profundus flexor tendons, which are fused over a fair portion of

their course; second, the junctura of the extensor tendons; and third, the lumbrical muscles which exert a modifying and integrating action on both systems. The restricting action of the flexor system is manifested chiefly at the interphalangeal joints, that of the extensor system at the metacarpophalangeal joints.

The practical application of this is as follows:

1. After extensor-tendon repair on the back of the hand, wrist, or forearm, the involved finger should be splinted in moderate flexion at both interphalangeal joints, so that it is placed in a more functional position. The uninvolved fingers are thereby released so that they can be placed in moderate flexion at all three joints and can move actively to some extent.

2. After extensor-tendon repair on the dorsum of the finger itself (except in the distal segment), the injured fingers should be placed in extension (175 degrees) at both the metacarpophalangeal and proximal interphalangeal joints. The distal joint should be allowed slight flexion and, if this is done, some differential flexion of the remaining fingers is possible, even when the tendon-bound ring finger is the injured one.

These facts are easily demonstrated on one's own hand, and are essential for the intelligent application of the dictum in surgery of the hand to keep uninjured parts moving, if possible.

Joint Motion

The cause of stiffness in immobilized joints, as pointed out by Watson-Jones, is not so much immobility itself as cessation of functional activity around joints. Venous and lymphatic stasis leads to waterlogging of periarticular tissues with serofibrinous exudates which later become organized to form fibrous adhesions and thickened joint capsules.

It is well known that, if a wrist joint is immobilized for many months for fracture of the navicular bone, it is amazingly supple when removed from plaster, provided the fingers have been kept active during this period. This principle, namely, that the continued functional activity of joints distal and proximal to immobilized joints is beneficial to the latter, should be applied whenever feasible after surgery of the hand. For example, if the metacarpophalangeal joints must be kept at rest, even small degrees of motion of the interphalangeal joints will tend to minimize stiffness of the metacarpophalangeal joints when released. Motion in uninjured digits should likewise be helpful in this respect, by promoting the general return circulation (venous and lymphatic) in the hand.

In 1862 John Hilton in his lectures on Rest and Pain made this statement:

"Many persons . . . believe that the joints, their soft parts especially, being unused and kept in restraint, although not at the time actually diseased, may suffer irreparable structural change or deterioration by long continued rest, and that healthy joints may become anchylosed as the consequence solely of that rest. This opinion is advanced as an argument against the employment of long-continued rest to diseased joints. Now, I doubt the soundness of this conclusion; nay, indeed, I believe that it is essentially untrue. It is possible, and may be probable, that a temporary alteration and a diminished elasticity of articular cartilage may occur; that the ligaments may become feeble, and the synovial membrane unmindful of its duties, without the stimulus of friction; that the bones may lose their firmness, and the muscles their strength, from disuse; but such deteriorations are only temporary. . . ."

In mid-Victorian England, Hilton was dealing with gross disease of the joints of the lower extremity. He was a pioneer in the treatment of tuberculous joints by immobilization. Because of the striking benefit of rest to diseased joints, he was skeptical of the deleterious effects of rest on normal joints, but his doubts on this point are apparent in the above quotation. Today we have overwhelming proof of the harmful effect of immobility on normal joints, especially in those of the hand.

SUMMARY

The problems of postoperative position and motion in the hand must be solved with an appreciation of the inherently dynamic function of the hand as opposed to the

essentially static nature of splinting. The wrist joint is especially vulnerable to injury by restraint in the acutely flexed position, and the finger joints are liable to damage if left in full extension. Judicious splinting in the correct position, with uninterrupted activity of the uninjured portion of the hand and early activation of the injured portion will lead to favorable results. Overlong restraint of the hand in any position will lead to stiffness, which in a non-functional position is doubly disastrous.

The hand is like a bird and it strongly resents being caged. If caged too long, it may not fly again.

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The Role of Muscle Contraction or Intrinsic Forces in the Causation of Fractures of the Femoral Neck *

BY L. D. SMITH, M.D., MILWAUKEE, WISCONSIN

From the Laboratory of the Engineering School of Marquette University, Milwaukee

A woman, fifty years old, was closing the gate to her cow pasture when a young heifer tried to escape. The woman made a sudden movement to prevent this and felt something "give" in her left hip. She kept herself from falling by holding onto the gate, but she was unable to move the left thigh. She had sustained a fracture of the left femoral neck. Obviously this was not due to a fall but to a sudden muscle contraction, associated with the hurried effort to close the gate. Similarly, a woman, sixty-three years old, stepped out to drop a letter in the mail box in front of her house. The walk was icy and she lost her balance, but she did not fall. As she caught herself she felt something "snap" in her right hip. She grasped the mail box but gradually subsided to a sitting position. She was unable to move her right thigh. She had fractured the neck of her right femur. Again it was muscle violence and not a fall which produced this fracture.

FIG. 1-A

FIG. 1-B

Fig. 1-A: In a clinical cervical fracture of the femur, the prominence of the lesser trochanter indicates the degree of external rotation of the distal fragment — that is, the femoral shaft. In this instance it amounts to about 75 degrees. In the neutral position or internal rotation of the femur (Figs. 16 and 18), the lesser trochanter would appear either as a slightly curved line or would disappear completely, and the neck would appear longer as the foreshortening projection of the cervical anteversion is corrected by its parallelism to the film (Fig. 18).

The fracture here depicted is an oblique cervical fracture (Figs. 2 and 22) with superimposition of the proximal fragment. The thigh muscles have externally rotated the distal fragment and drawn it upward. Muscle spasm may temporarily "lock" the fragments in place. A less penetrating x-ray film of the same specimen (Fig. 1-C) would fail to show the superimposition of fragments here depicted and would indicate a more or less conglomerate fragmentation. These phenomena may have given rise to misuse of the term "impaction", or "impacted fracture of the hip".

Figures 1-A, 1-B, and 1-C are different aspects of the same specimen.

Fig. 1-B: This is the same specimen as that shown in Fig. 1-A with slightly less external rotation of the distal fragment. The diminished prominence of the lesser trochanter (see its disappearance in Figs. 15 and 16) and the decreased superimposition of the fracture fragments is apparent.

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 31, 1951. Revised paper for publication received January 19, 1953.

FIG. 1-C

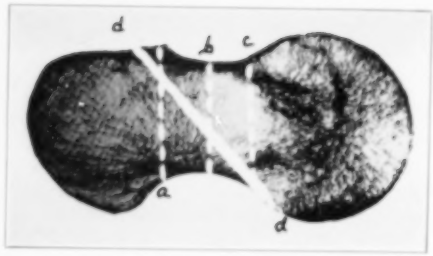


FIG. 2

Fig. 1-C: This is again the same specimen as that shown in Fig. 1-A. The roentgenogram has been made with less penetration. This appearance, especially if the fracture is "locked" by muscle spasm, is frequently erroneously referred to as an "impacted fracture of the hip".

Fig. 2: Cervical fractures are frequently oblique (Fig. 22) and may simulate a subcapital (*a*), transcervical (*b*), or basal fracture of neck (*c*), depending upon the angle of the x-ray projection (Figs. 1-A, 1-B, and 1-C).

The oblique plane (*d*) may simulate the appearance of "impaction" as seen in Fig. 1-C.

The history usually given in fractures of the femoral neck is that the patient fell and injured the hip, the implication being that the fall preceded and caused the injury. External violence, such as falling from a height, vehicular accidents to passengers or pedestrians, and industrial accidents frequently result in pelvic, acetabular, trochanteric, and other fractures rather than femoral-neck fractures. Characteristically these fractures of the femoral neck occur in the patient's home during the performance of usual daily activities. This is a constant pattern, while falls and limb-shortening are seen only occasionally and are secondary.

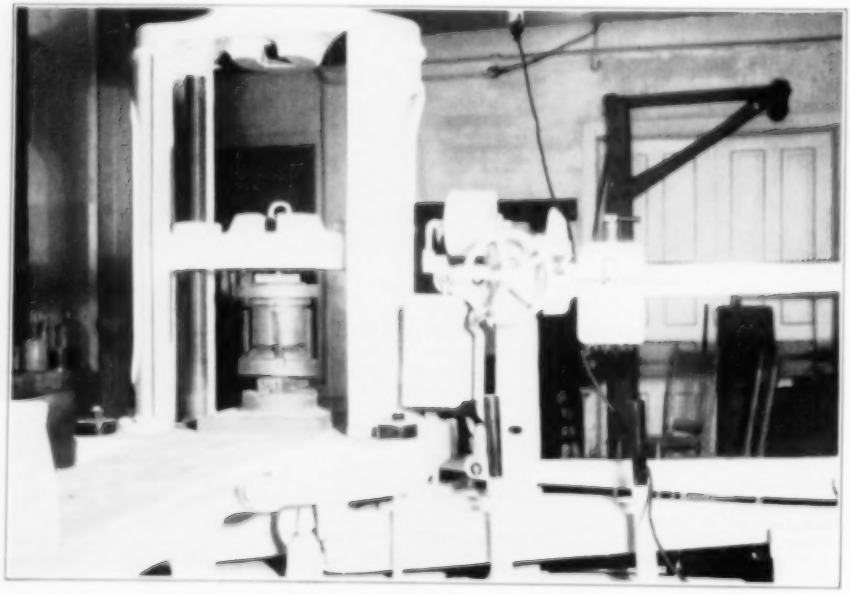


FIG. 3

Power press at Marquette University Engineering School. This press was used to produce controlled fractures in femora of human cadavera (Figs. 4, 5, 6, 7, 8, and 9).

Fig. 4: Vertical pressure upon the heads of eight upright femora simulated the action of external violence in life.

a: Fracture of head extending into the neck;
b: Intertrochanteric fracture;
c: Subtrochanteric fracture;
d: Old healed cervical fracture;
e: Line of applied force from the press;
f: Lesser trochanter is the fulcrum for vertical forces applied to femoral head;
g: Arc of tissue tension in head, neck, and greater trochanter, tending to produce tissue separation;
h: A building brick to prevent slipping of the femur.

Specimen 1. 1,130 pounds. Shearing fracture *a* and tension fracture *c*.
Specimen 2. 2,630 pounds. Fracture *a*.
Specimen 3. 970 pounds. Fracture *c*.
Specimen 4. 2,180 pounds. Fracture *a* but the neck was intact.
Specimen 5. 1,076 pounds. Old healed cervical fracture *d*. Fractures *a* and *b*.
Specimen 6. 4,210 pounds. Fracture *c*.
Specimen 7. 2,470 pounds. Fracture *b*.
Specimen 8. 2,070 pounds. Fracture *c*.
The greatest force required was 4,210 pounds.
The least force required was 970 pounds.
The average force required was 2,092 pounds.

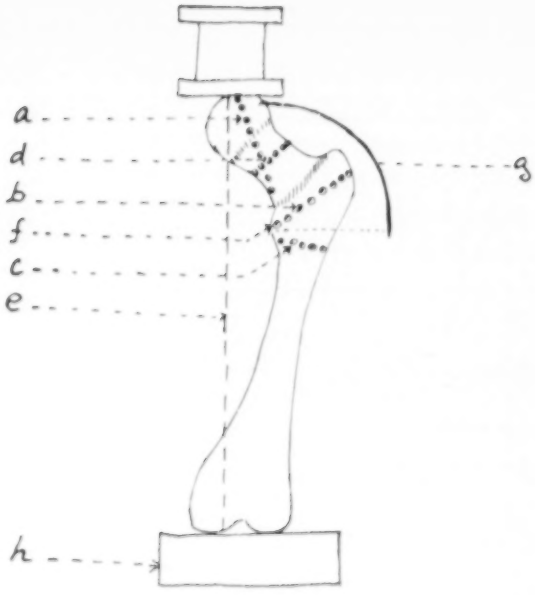


FIG. 4

There are three constants associated with fractures of the femoral neck: (1) the orthostatic position of the patient just before injury, (2) the inability of the patient to move the leg after injury, and (3) the usual external rotation of the affected leg.

Roentgenograms of the hip typically show a transverse or transverse oblique fracture of the femoral neck with the lesser trochanter prominent and the distal fragment displaced upward (Figs. 1-A and 2).

It seemed logical to assume that, if a transverse fracture of the neck of the femur is produced by external violence in the living patient, similar fractures should be produced in human femora subjected to similar forces in the laboratory. A series of experiments were set up and were carried out in the Engineering School of Marquette University. One hundred and fifteen human femoral necks and hip joints were subjected to pressures and to impacts to learn why or how hips were broken through the visitation of external violence.

Embalmed specimens of disarticulated femora and of femora still articulated with the pelvis were used. There was considerable variation in the ages of the individuals from which the specimens were taken and, of course, in the condition of the bones. As a result, there was a great variation in the strength of the specimens as is shown by the rather wide range of loads and impacts required to produce fractures. No attempt was made to determine the cause of death in each instance, but there was no gross pathological condition of the skeletal system in the individuals from whom the specimens were taken. These factors are not considered to introduce any significant error in the experiments in which the average or "mean" was used. The same sources of error were present in all series.

Experiment 1

Through the use of the power press (Fig. 3), gradually increasing pressures were applied to human femora in various positions. Starting at zero, the investigators increased pressure until fracture occurred, at which point the pressure was recorded.

A. Forty-three human femora were subjected to pressures imitating the action of external or extrinsic force upon the hip joint. Pressures were applied (1) downward on

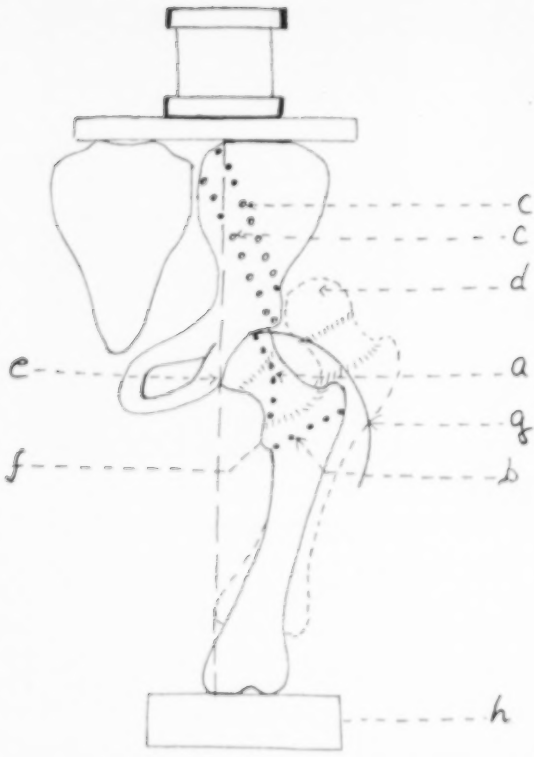


FIG. 5

Fig. 5: Vertical pressures acting indirectly through the pelvis upon fourteen femoral heads simulated the action of external violence in life.

a: Head fractures extending into the neck;
b: Intertrochanteric fractures;
c: Iliac fractures;
d: Dislocation of hip;
e: Line of applied force from the press;
f: Lesser trochanter is the fulcrum for vertical forces applied to femoral head;
g: Arc of tissue tension in head, neck, and greater trochanter, tending to produce tissue separation;
h: A building brick to prevent slipping of the femur.

Specimen 1. 2,700 pounds. Fracture *b*.
Specimen 2. 2,340 pounds. Fracture *b*.
Specimen 3. 2,600 pounds. Fracture *b*.
Specimen 4. 3,300 pounds. Fracture *a*.
Specimen 5. 1,360 pounds. Fracture *a*.
Specimen 6. 3,495 pounds. Fracture *a*.
Specimen 7. 1,000 pounds. Fracture *b*.
Specimen 8. 1,100 pounds. Fracture *c*, crack of the femoral neck.
Specimen 9. 3,100 pounds. Dislocation *d*, brick (*h*) crushed.
Specimen 10. 2,230 pounds. Dislocation *d*.
Specimen 11. 1,970 pounds. Fracture *c*, neck.
Specimen 12. 1,080 pounds. Fracture *c*, comminuted.
Specimen 13. 1,400 pounds. Fracture *c*, comminuted.
Specimen 14. 2,500 pounds. Fracture *c*, comminuted.
The greatest force required was 3,495 pounds.
The least force required was 1,000 pounds.
The average force required was 2,149 pounds.

the vertically placed femur, both directly upon the head of the disarticulated femur and upon the ilium with the hip joint intact, and (2) in the frontal and sagittal planes on the greater trochanter both on the femur alone and on the femur with the joint intact.

The results of these experiments are summarized in Figures 4, 5, 6, and 7. In no instance was a cervical fracture produced. In the forty-three femora tested, twenty-four trochanteric, two head, and sixteen pelvic fractures, and two hip dislocations resulted. The average load necessary for fracture to occur was 1,994.2 pounds.

B. Twenty femora were subjected to torques applied to the femoral neck by means of the power press (Fig. 3) and the T-shaped and U-shaped pieces of iron shown in Figures 8 and 9. These torques simulated the intrinsic forces resulting from muscle contraction of the external rotators of the hip which produce an anterior bending moment across the femoral neck (Fig. 20-B, *e*). The results of this experiment are summarized in Figure 10. It will be seen that in every instance a fracture of the femoral neck, comparable to those seen clinically, was produced by an average load of 900 pounds.

Experiment 2

By means of a disc, weighing 117 pounds, and a windlass (Fig. 11), sudden blows or impacts were applied by cutting the rope and allowing the disc to fall on the specimen from increasing heights until fracture occurred. These sudden impacts or blows simulated those received in falls upon the hip in life. This method is open to some error in that when the first impact fractured the bone, a lesser one might have done so, while if successively increasing heights were required, the earlier blows might have weakened the specimen. However, in a series the overestimate from the first cause of error would tend to be balanced out by the underestimate of the second cause of error. In any case

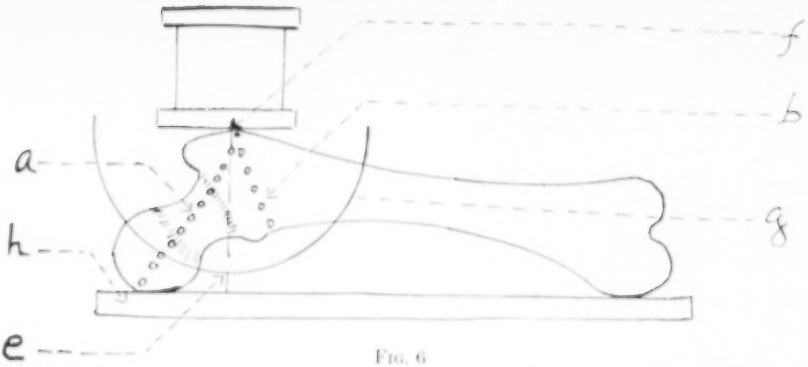


FIG. 6

Lateral pressures were applied upon the greater trochanters of ten disarticulated femora in the horizontal position, simulating the action of external violence due to a blow or fall on the hip.

a: Head fractures extending into the neck;
b: Intertrochanteric fracture;
e: Line of applied force from the press;
f: Fulcrum for the forces applied to the greater trochanter in the frontal plane;
g: Arc of tension in head, neck, and lesser trochanter, tending to produce tissue separation;
h: Smooth steel plate to minimize friction and permit springing or bowing of the specimen.

Specimen 1. 1,150 pounds. Fractures *a* and *b* combined.
Specimen 2. 2,190 pounds. Fracture *b*.
Specimen 3. 3,380 pounds. Fractures *a* and *b* combined.
Specimen 4. 1,390 pounds. Fracture *b*.
Specimen 5. 1,180 pounds. Fracture *b*.
Specimen 6. 600 pounds. Fracture *b*.
Specimen 7. 700 pounds. Fractures *a* and *b* combined.
Specimen 8. 3,260 pounds. Fracture *b*.
Specimen 9. 920 pounds. Fracture *b*.
Specimen 10. 1,710 pounds. Fracture *b*.
The greatest force required was 3,380 pounds.
The least force required was 600 pounds.
The average force required was 1,648 pounds.

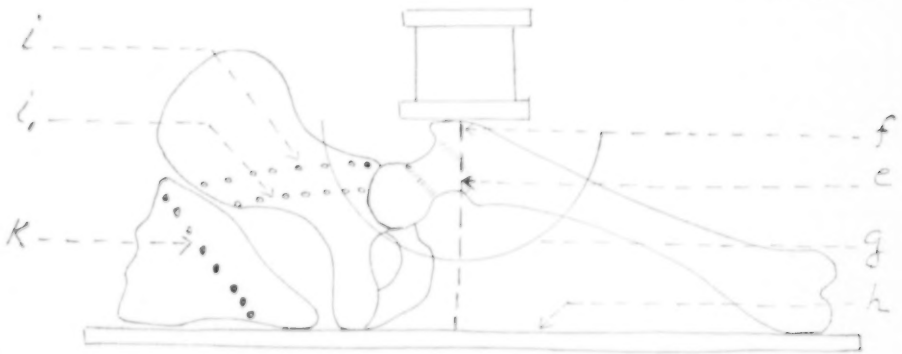


FIG. 7

Lateral pressures were applied upon the greater trochanter of eleven articulated femora in the horizontal position, simulating the action of external violence in life.

i: Fractures in the innominate bone;
i_1: Fracture through the acetabulum;
j: Fractures through the symphysis pubis;
k: Fracture through the sacrum;
e: Line of applied force from the press;
f: Fulcrum for the force acting upon the femur and pelvis;
g: Arc of tissue tension in lesser trochanter, neck, acetabulum, and pelvis, tending to produce tissue separation;
h: Smooth steel plate.

Specimen 1. 2,000 pounds. Fractures *i* and *j*.
Specimen 2. 2,000 pounds. Fractures *i* and *j*.
Specimen 3. 1,560 pounds. Fractures *i* and *j*.
Specimen 4. 1,035 pounds. Fractures *i* and *j*.
Specimen 5. 645 pounds. Fracture *k*, crushing of sacrum.
Specimen 6. 2,750 pounds. Fracture *i*.
Specimen 7. 2,200 pounds. Fractures *i* and i_1.
Specimen 8. 2,800 pounds. Fractures *i* and *k*.
Specimen 9. 3,600 pounds. Fracture *i*.
Specimen 10. 3,100 pounds. Fracture *i*.
Specimen 11. 700 pounds. Fracture *i* through symphysis pubis.
The greatest pressure required was 3,100 pounds.
The least pressure required was 645 pounds.
The average pressure required was 2,035 pounds.

the error is small and is absorbed by the "mean" of a number of experiments. Moreover, the errors are common to each of the series being compared.

A. Experiment *1,A*, was repeated with sudden blows or impacts. The results are

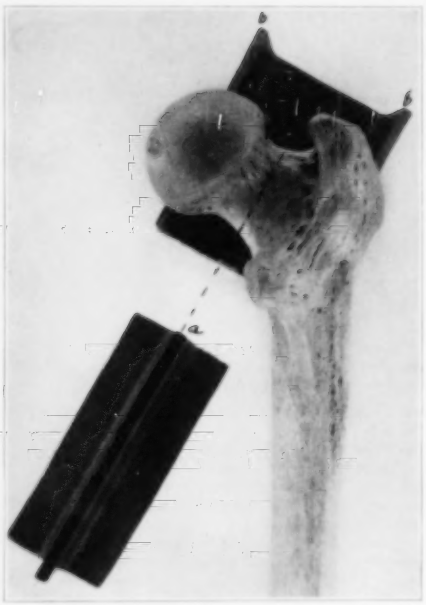


FIG. 8

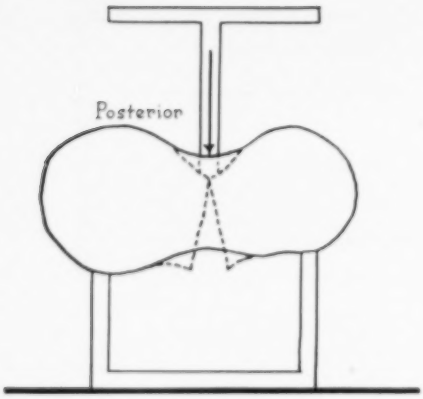


FIG. 9

Fig. 8: Iron wedges were used to produce fracture of the cervix. By forcibly pressing the iron flange (*a*) down upon the cervix, a cervical fracture can be produced (Figs. 2, 9, and 21). This mechanism simulates the external rotatory muscle strain upon the neck of the femur, and is the only artificial method by which cervical fractures could be produced.

Fig. 9: The action of the iron flanges is shown. The bending moment of the external rotator muscles (Fig. 20-B) upon the cervix is exhibited here.

Thirteen fractures of the femoral neck (clinical) occurred in thirteen femora under an average impact of 37 foot pounds.

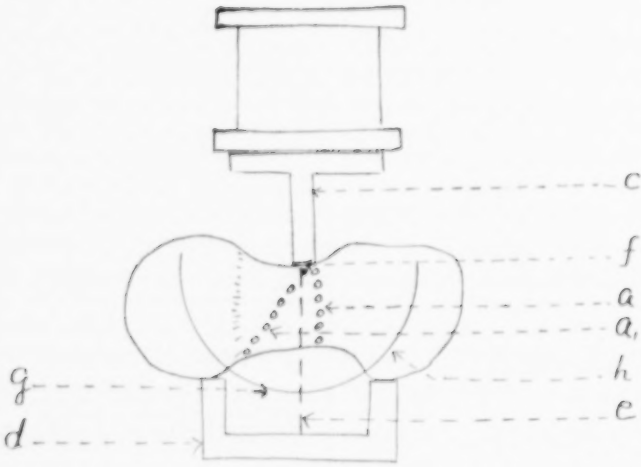


FIG. 10

Fig. 10: Pressures were applied across the necks of twenty horizontally placed femora, T-shaped and U-shaped flanges being used to simulate torque and anterior bending moment produced by contraction of the external rotators.

a: Transverse cervical fracture;
a_1: Oblique cervical fracture;
c: T-flange on posterior aspect of neck;
d: U-flange on anterior aspect of neck;
e: Line of applied force from press;
f: Fulcrum of force applied to posterior neck;
g: Arc of tissue tension, tending to produce separation of tissue anteriorly;
h: External rotation of trochanter and shaft.

Specimen 1.	1,040 pounds.	Fracture *a*.
Specimen 2.	870 pounds.	Fracture *a*.
Specimen 3.	2,400 pounds.	Fracture *a*.
Specimen 4.	1,100 pounds.	Fracture *a*.
Specimen 5.	890 pounds.	Fracture a_1
Specimen 6.	850 pounds.	Fracture a_1.
Specimen 7.	710 pounds.	Fracture a_1.
Specimen 8.	770 pounds.	Fracture a_1.
Specimen 9.	770 pounds.	Fracture a_1.
Specimen 10.	790 pounds.	Fracture a_1.
Specimen 11.	970 pounds.	Fracture a_1.
Specimen 12.	910 pounds.	Fracture a_1.
Specimen 13.	800 pounds.	Fracture a_1.
Specimen 14.	660 pounds.	Fracture *a*.
Specimen 15.	670 pounds.	Fracture *a*.
Specimen 16.	810 pounds.	Fracture *a*.
Specimen 17.	510 pounds.	Fracture a_1.
Specimen 18.	940 pounds.	Fracture a_1.
Specimen 19.	770 pounds.	Fracture *a*.
Specimen 20.	770 pounds.	Fracture *a*.

The greatest force required was 2,400 pounds.
The least force required was 510 pounds.
The average force required was 900 pounds.

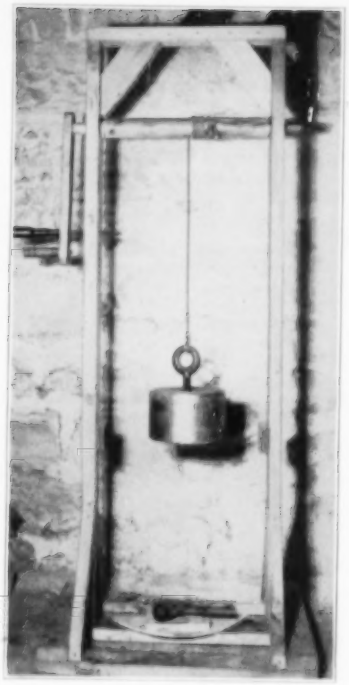


FIG. 11

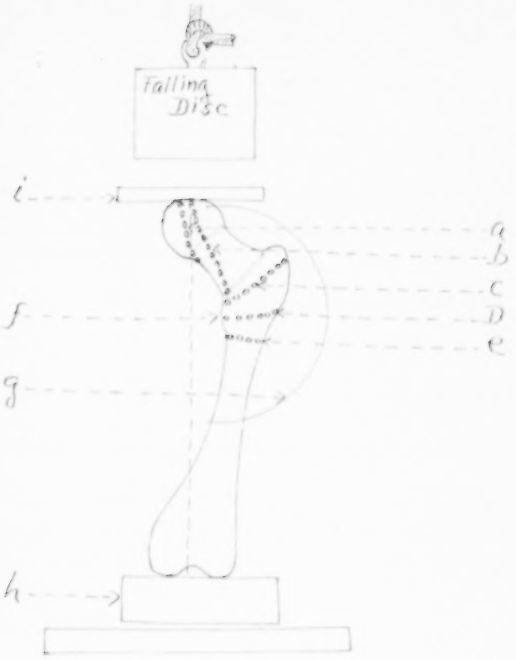


FIG. 12

Fig. 11: A disc, weighing 117 pounds, was used to produce falling blows or impacts. The disc was made to fall upon the hip joint, which was placed at various angles, by cutting the supporting string.

Fig. 12: Blows on the heads of eight upright, disarticulated femora simulated action of external violence.

a: Head fracture;
b: Head and neck fracture;
c: Intertrochanteric fracture;
d: Subtrochanteric fracture;
e: Shaft fracture;
f: Lesser trochanter is the fulcrum for vertical forces applied to head;
g: Arc of tissue tension in head, neck, trochanter, and upper shaft, tending to produce tissue separation;
h: A building brick;
i: A soft pine board, one inch by four inches.
Specimen 1. 306 foot pounds. Fracture *d*.
Specimen 2. 345 foot pounds. Fracture *a*.
Specimen 3. 230 foot pounds. Fractures *b* and *c* combined.
Specimen 4. 345 foot pounds. Fracture *a*.
Specimen 5. 345 foot pounds. Fractures *b* and *c* combined.
Specimen 6. 350 foot pounds. Fractures *a* and *e* combined.
Specimen 7. 350 foot pounds. Fractures *b* and *d* combined.
Specimen 8. 345 foot pounds. Fracture *b*.
The greatest impact required was 350 foot pounds.
The least impact required was 230 foot pounds.
The average impact required was 327 foot pounds.

summarized in Figures 12, 13, and 14. It will be seen that one pelvic, twenty-eight trochanteric, and three femoral-head fractures were produced, as well as seven dislocations of the hip, with an average impact of 290.2 foot pounds.

B. With the falling disc and the iron flanges (Figs. 8 and 9), Experiment *1,B*, was repeated on thirteen femora. In each case a fracture of the femoral neck, simulating those seen clinically, was produced. The results are summarized in Figure 15. The average impact was thirty-seven foot pounds.

The results of all experiments are summarized in Tables I-A, I-B, and I-C.

DISCUSSION

In a clear roentgenogram of the pelvis (Fig. 16) the anteroposterior view will show trabeculae which indicate lines of stress which extend from the subtrochanteric region through the long axis of the neck into the ilium and which curve medially across the

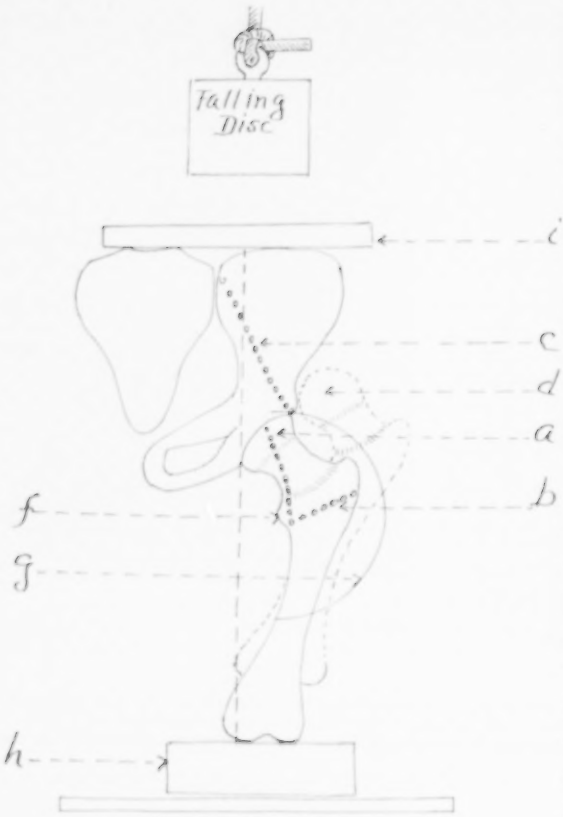


FIG. 13

Fig. 13: Blows upon eighteen upright articulated femora through the pelvis and acetabulum simulated the action of external violence in life.
a: Intertrochanteric fracture which extended horizontally into the neck and head;
b: Intertrochanteric fracture;
c: Fracture of ilium;
d: Dislocation of hip;
f: Lesser trochanter which is the fulcrum of the vertical forces applied to head;
g: Arc of tissue tension in head, neck, and upper shaft, tending to produce tissue separation;
h: A building brick;
i: A soft pine board, one inch by four inches.
Specimen 1. 125 foot pounds. Fracture *b*.
Specimen 2. 345 foot pounds. Fracture *b*.
Specimen 3. 345 foot pounds. Fracture *b*.
Specimen 4. 345 foot pounds. Fracture *b*.
Specimen 5. 345 foot pounds. Fracture *b*.
Specimen 6. 125 foot pounds. Fractures *b* and *a*.
Specimen 7. 125 foot pounds. Fractures *b* and *a*.
Specimen 8. 125 foot pounds. Fractures *b* and *a*.
Specimen 9. 125 foot pounds. Fractures *b* and *a*.
Specimen 10. 125 foot pounds. Fractures *b* and *a*.
Specimen 11. 230 foot pounds. Dislocation *d*.
Specimen 12. 230 foot pounds. Dislocation *d*.
Specimen 13. 230 foot pounds. Dislocation *d*.
Specimen 14. 345 foot pounds. Dislocation *d*.
Specimen 15. 345 foot pounds. Dislocation *d*.
Specimen 16. 345 foot pounds. Dislocation *d*.
Specimen 17. 345 foot pounds. Dislocation *d*.
Specimen 18. 230 foot pounds. Fracture *c*.

The greatest impact required was 345 foot pounds.
The least impact required was 125 foot pounds.
The average impact required was 250 foot pounds.

TABLE I-A

PRESSURES SIMULATING EXTRINSIC VIOLENCE UPON THE UPRIGHT AND HORIZONTAL FEMUR

	No. of Specimens	Trochanteric Fractures	Femoral-Head Fractures	Ilium Fractures	Hip Dislocations	Transverse Femoral-Neck Fractures	Average Load or Impact Required to Produce Fracture
			Vertical Pressures upon Upright Femora				
Disarticulated	8	7	2				2092 lbs.
Through pelvis	14	7		5	2		2149 lbs.
			Lateral Pressures upon Horizontal Femora				
Disarticulated	10	10					1648 lbs.
Through pelvis	11			11			2034 lbs.
						Average	1994.6 lbs.
Total	43	24	2	16	2		

TABLE I-B

BLOWS UPON THE FEMUR SIMULATING EXTRINSIC VIOLENCE

	No. of Specimens	Trochanteric Fractures	Femoral-Head Fractures	Ilium Fractures	Hip Dislocations	Transverse Femoral-Neck Fractures	Average Load or Impact Required to Produce Fracture
			Blows upon Upright Femoral Heads				
Disarticulated	8	6	3				327 ft. lbs.
Through pelvis	17	9		1	7		250 ft. lbs.
			Blows upon Horizontal Femora				
Laterally upon trochanter	13	13					306 ft. lbs.
						Average	290.2 ft. lbs.
Total	39	28	3	1	7		

superior part of the sacrum to meet similar trabeculae from the opposite side at the apex of a fair arch.

It is peculiar to an arch (Fig. 17) that radial forces or forces exerted in its frontal plane against its periphery are translated into tangential forces that are absorbed as thrusts within its structure. External force then can be absorbed by the femoral neck only

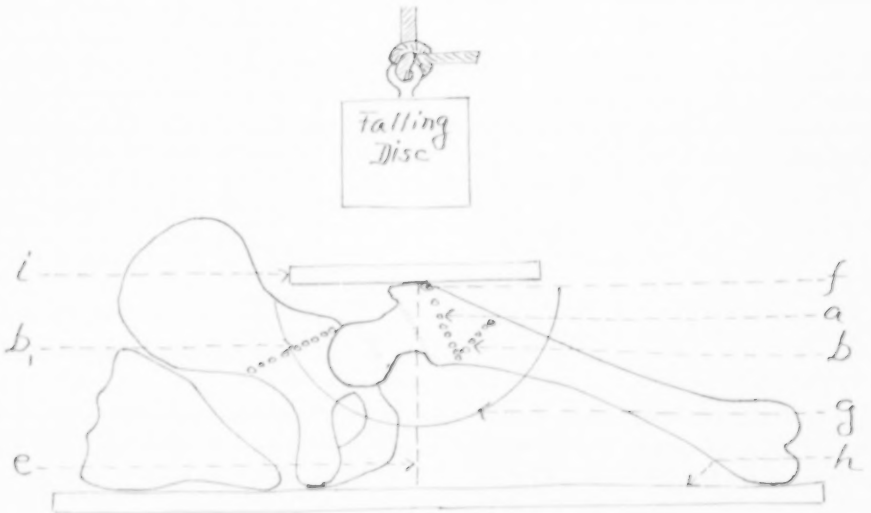


FIG. 14

Blows were applied to the greater trochanter of thirteen horizontally placed articulated femora, simulating the action of external violence.

a: Intertrochanteric fracture;
b-b1: Fracture of the shaft, acetabulum, and ilium;
e: Line of applied force;
f: Fulcrum for the force acting upon femur and pelvis;
g: Arc of tissue tension;
h: Smooth steel plate;
i: A soft pine board, one inch by four inches.
Specimen 1. 288 foot pounds. Fracture *a*.
Specimen 2. 345 foot pounds. Fracture *a*.
Specimen 3. 187 foot pounds. Fracture *a*.
Specimen 4. 172 foot pounds. Fracture *a*.
Specimen 5. 345 foot pounds. Fracture *a*.
Specimen 6. 401 foot pounds. Fracture *a*.
Specimen 7. 460 foot pounds. Fracture *a*.
Specimen 8. 230 foot pounds. Fracture *a*.
Specimen 9. 288 foot pounds. Fracture *a*.
Specimen 10. 288 foot pounds. Fracture *a*.
Specimen 11. 288 foot pounds. Fracture *a*.
Specimen 12. 401 foot pounds. Fracture *a*.
Specimen 13. 288 foot pounds. Fractures *a*, *b-b1*.
The greatest impact required was 460 foot pounds.
The least impact required was 172 foot pounds.
The average impact required was 306 foot pounds.

TABLE I-C

PRESSURES SIMULATING INTRINSIC VIOLENCE UPON THE NECK OF PRONE FEMORA

	No. of Specimens	Trochanteric Fractures	Femoral-Head Fractures	Ilium Fractures	Hip Dislocations	Transverse Femoral-Neck Fractures	Average Load or Impact Required to Produce Fracture
Pressure applied transversely	20					20	900 lbs.
Blows upon the Neck of Prone Femora Simulating Intrinsic Violence							
Blows applied transversely	13					13	37 ft. lbs.

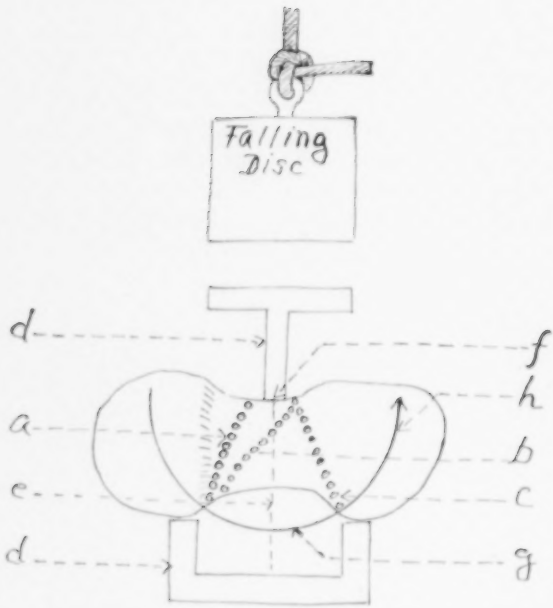


FIG. 15

Fig. 15: Blows across the necks of thirteen prone femora imitated the torque or forward bending moment produced by contraction of the external rotator muscles upon the femoral neck in life.

a: Subcapital fracture;
b: Transverse oblique fracture;
c: Base of neck fracture;
d: T and U flanges (Figs. 8 and 9);
e: Line of applied force;
f: Fulcrum of acting force;
g: Arc of tissue tension tending to produce anterior tissue separation;
h: External rotation of greater trochanter and femoral shaft.

Specimen 1. 75 foot pounds. Fracture *b*.
Specimen 2. 28 foot pounds. Fracture *b*.
Specimen 3. 37 foot pounds. Fracture *b*.
Specimen 4. 28 foot pounds. Fracture *a*.
Specimen 5. 28 foot pounds. Fracture *c*.
Specimen 6. 18 foot pounds. Fracture *c*.
Specimen 7. 28 foot pounds. Fracture *a*.
Specimen 8. 37 foot pounds. Fracture *c*.
Specimen 9. 46 foot pounds. Fracture *b*.
Specimen 10. 28 foot pounds. Fracture *a*.
Specimen 11. 28 foot pounds. Fracture *b*.
Specimen 12. 46 foot pounds. Fracture *a*.
Specimen 13. 46 foot pounds. Fracture *b*.

The greatest impact required was 75 foot pounds.
The least impact required was 18 foot pounds.
The average impact required was 36.4 foot pounds.

in the frontal plane of the pelvic arch. Further scrutiny of the femoral neck in the roentgenogram (Fig. 18) and in Ward's diagram (Fig. 19) will show three systems of trabeculae, all placed in the frontal plane. In Figure 18, *A* forms an arch with B_1 within the greater trochanter and *B* serves as the springer * of the pelvic arch (Fig. 17). It will also be noted that *B* forms an arch with B_1 within the head, neck, and trochanter. In Figures 18 and 20-A, the trigonum internum femoris, or Ward's triangle, is seen as an area of lessened density in the middle of the femoral neck.

In the horizontal section of the trochanter, neck, and head (Fig. 20-A), a rudimentary trabecular system is seen. Its lines converge to an apex posteriorly behind the structurally weak trigonum internum femoris in the middle of the neck.

Furthermore, the vertical diameter of the femoral neck (Fig. 18) is one third larger than the horizontal diameter (Fig. 20-A). This indicates a dimensional response to weight-bearing and external forces, as does the trabecular system in the femoral neck. In short,

* The springer (Fig. 17) is the lowermost portion of an arch which rests upon the top member of the pillar or impost upon which the weight of the arch rests.

Fig. 16: Lines of trabeculation in the femur and pelvis form a parabolic arch. The retouched lines of trabeculation are seen to form a parabolic arch (Fig. 17). They are commonly apparent in the femoral neck and ilium in an anteroposterior roentgenogram of the hip and pelvis. In the upper segment of the sacrum where the cross-section volume is greater, they are dispersed and are less dense and hence less apparent, but are nonetheless easily discernible with penetrating x-ray technique in the pelvis of a vigorous person with bones of high calcium content.

Fig. 16

the small horizontal diameter, the area of lessened density or Ward's triangle in the central neck, and the rudimentary trabecular system in the horizontal plane all serve to make the neck vulnerable to fracture from stresses in this plane.

The neck of the femur extends laterally from the pelvis in the frontal plane of the body. It thus provides a lever to which the external rotator muscles of the thigh are attached (Fig. 20-B). The femur offers no resistance to rotation when the limb is free. There is thus no great need for structural strength to provide for the anterior stresses in the horizontal plane of the femoral neck. In Figure 20-B, the pull of the rotator muscles (*a*) is exerted from the greater trochanter posteriorly and medially in a direction approximating the arc of rotation of the greater trochanter about the femoral head. The force exerted is absorbed in the rotation of the femur and in a compression thrust along the long axis of the neck, so that the head is firmly seated in the acetabulum. Thus there is no transverse stress or forward bending moment across the neck in the performance of normal free rotation of the thigh.

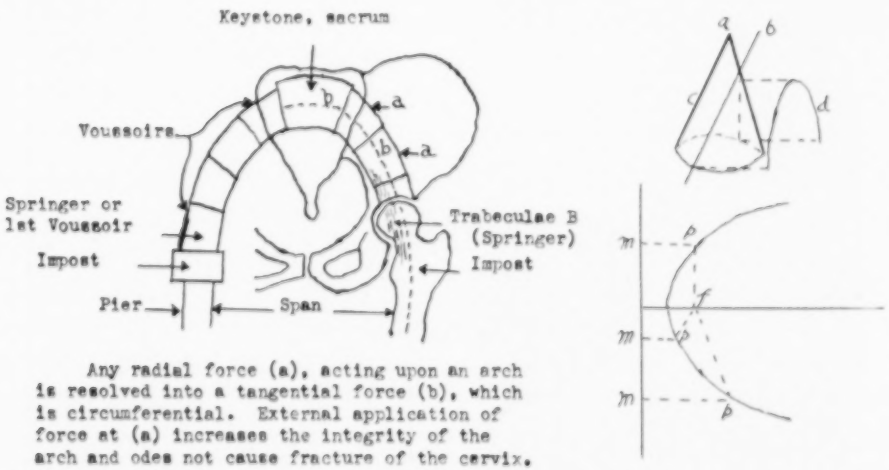


Fig. 17

The parabola (*bb*) is probably the strongest form of arch found in nature or used in architecture.

It is a conic section formed by cutting a cone (*a*) with a plane (*b*) parallel to one of its sides (*c*), forming the plane curve (*d*) in which the distance of any point (*p*) on it from a fixed focus (*f*) is equal to its distance from a point (*m*) on a fixed line, the directrix (*mm*).

It is expressed in the formula $Y^n = Kx^m$.

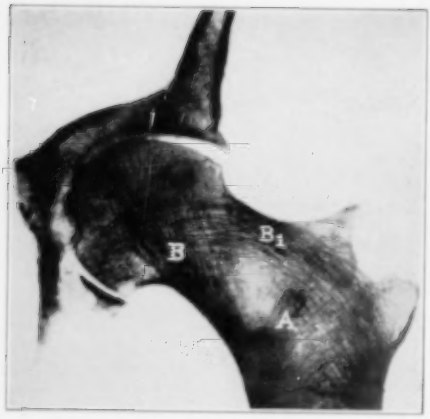


FIG. 18

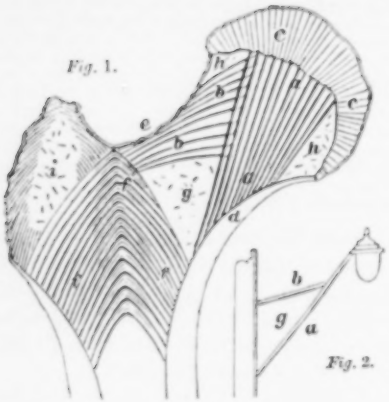


FIG. 19

Fig. 18: The three systems of trabeculation in the femoral neck are shown: *A* forms with B_1 an arch within the greater trochanter. *B*, the springer of the pelvic arch (Fig. 17), forms with B_1 an arch within the head, neck, and trochanter.

Fig. 19: Ward's diagram showing the triangle (from *Outlines of Human Osteology*, F. O. Ward, 1838).

Fig. 20-A: Trigonum internum femoris (Ward's triangle): A horizontal section of the femoral head, neck, and greater trochanter shows that the mid-section of the neck is volumetrically and structurally the weakest part in this plane.

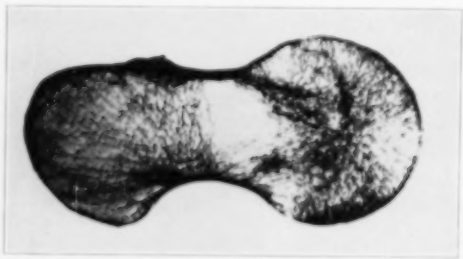


FIG. 20-A

Fig. 20-B: Resolution of external rotatory muscle forces:

a: Pull exerted by the external rotatory muscles;

b: Axis of rotation of the greater trochanter. The arc of rotation described by the greater trochanter in rotation of the femur is shown by b_1.

c: Element of *a* available to rotate the thigh in the acetabulum;

d: Element of *a* useless in external rotation of the thigh but exerting a shearing torque along the arc *d* e_1 about the center (*e*) with a forward bending moment indicated by the arrow at e_1. It is this element (*d*) which produces the fractures of the femoral neck seen clinically.

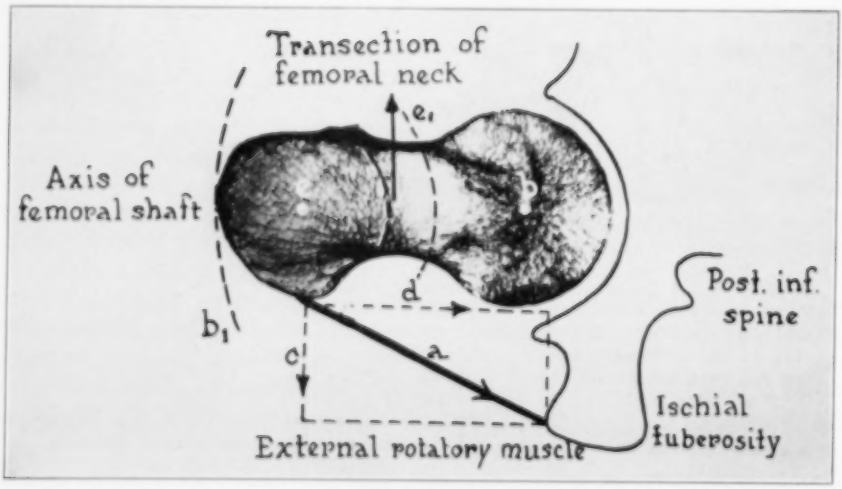


FIG. 20-B

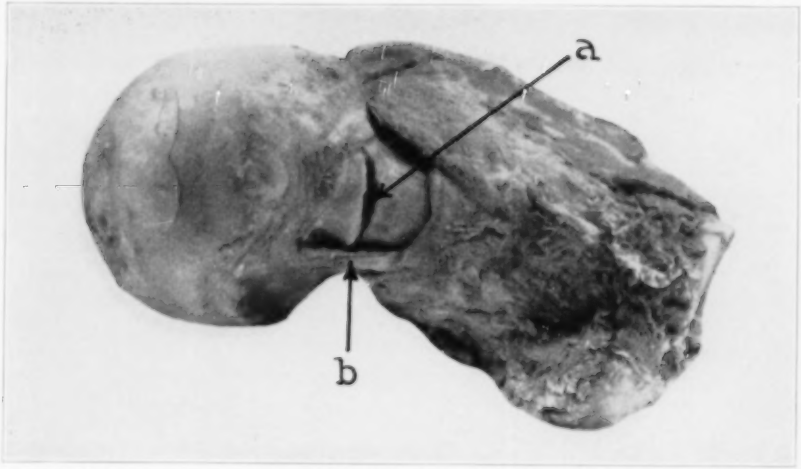


FIG. 21

Specimen of a fracture of the femoral neck eight weeks old shows the border of the retinaculum. The fracture was fixed with a four-flanged spike. The patient died with a heart condition eight weeks after the fracture. The spike is still in place, although it is not visible. The inferior border of the retinaculum is clearly seen at *b*. Bone healing is well advanced but still incomplete (*a*). The normal relationship of the fragments is maintained. The four-flanged spike is firmly embedded and resists removal. (The author uses a four-flanged spike in preference to a three-flanged spike. It can be milled in two operations instead of three, it possesses one third more friction surface, and, since it is stronger in cross section, it can be made lighter.)

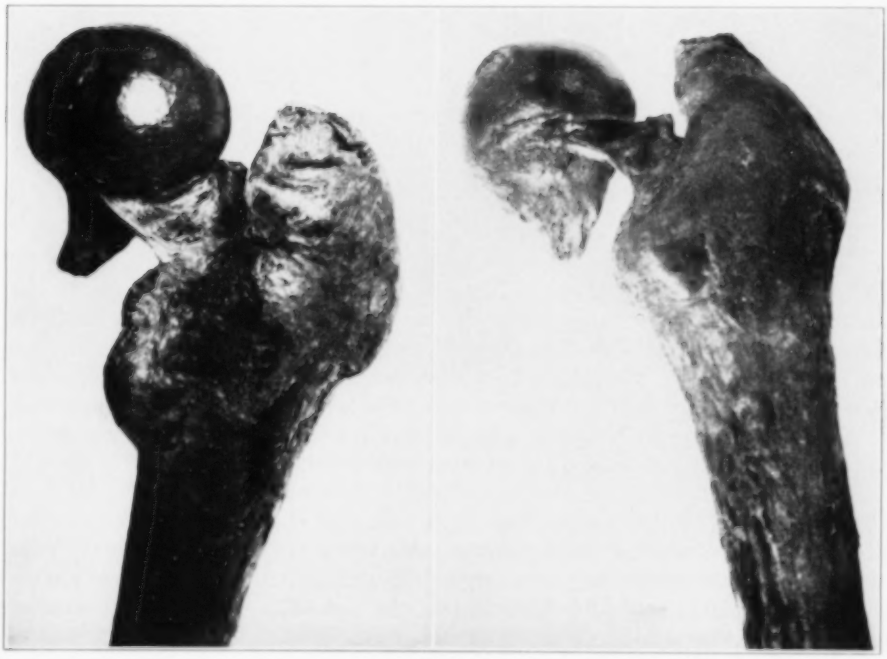


FIG. 22

The action of the retinaculum in an oblique fracture of the femoral neck is shown. In these posterior views, the hingelike action of the retinaculum is quite apparent.

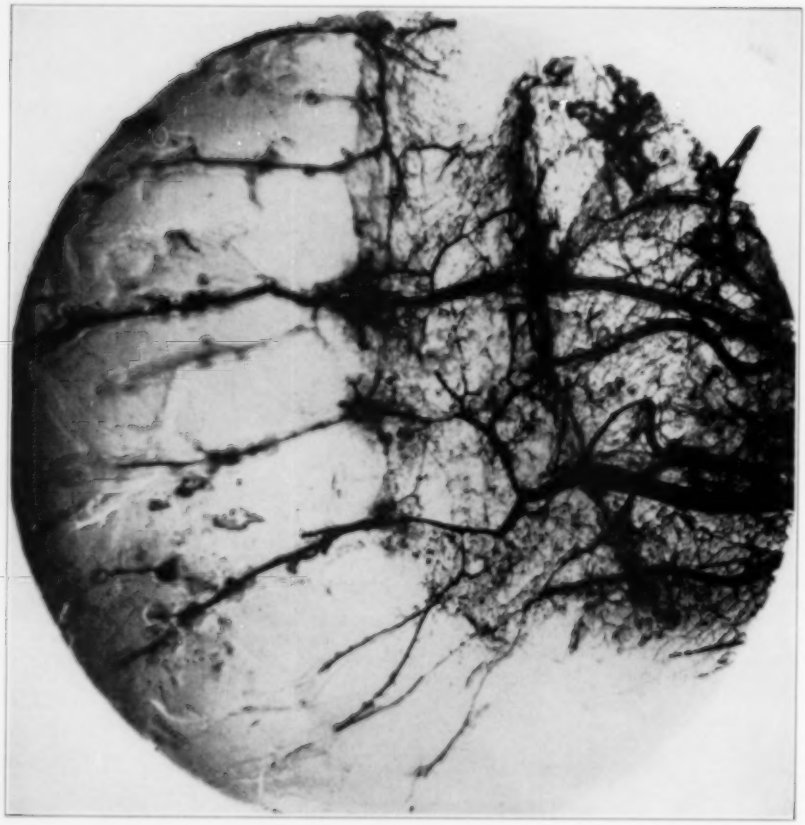


FIG. 23

Injected blood vessels in foetal retinaculum are shown. The specimen was from an almost full-term human foetus. The vessels were injected from an umbilical artery with cinnabar in water. The specimen was decalcified and cleaned. Much of the epiphysis and diaphysis was cut away, leaving only a relatively thin layer of tissue with vessels in and on it. The most superficial arteries are those relatively distinct. The dense arborization of vessels in the retinaculum indicates the importance of this structure for the blood supply to the head of the femur. (Photograph by courtesy of P. F. Swindle, Ph.D., Professor of Physiology, Marquette University School of Medicine.)

However, the neck of the femur is also part of a weight-bearing apparatus. In the orthostatic position, with the foot anchored to the floor by the weight of the body, the thigh cannot rotate. Contraction of the rotator muscles, with the extremity so fixed, acts as does the tightening of a bowstring—the femoral neck being the bow. This muscle contraction causes a forward bending moment across the neck in its weakest or horizontal plane (Fig. 20-B, *e*). If its strength is exceeded, it will break transversely or obliquely.

The displacement resulting from these transverse or oblique fractures of the femoral neck is determined in a large measure by the pull of the external rotators (Fig. 20-B, *e*) and the retinaculum of Weitbrecht (Figs. 21, *b* and 22). This retinaculum consists of fibers of the fibrous stratum of the posterior capsule, which are reflected proximally onto the neck of the femur where they form ridges. The retinaculum is ordinarily so closely attached to or applied to the underlying bone of the neck of the femur that it seems a part of it and presents a hard glistening surface. When fracture occurs, the retinacular fibers act as the binding of a book, and the fracture opens anteriorly much as do the leaves of a book (Figs. 21 and 22). Much of the blood supply to the femoral head is transmitted through the retinaculum or cervical ligament (Fig. 23). The degree of injury to

FIG. 24-A

FIG. 24-B

Fig. 24-A: The deformity of external rotation is increased to "unlock" the bone fragments, and at the same time manual traction is applied.

Fig. 24-B: External rotation is maintained with manual traction (see the surgeon's left hand). Abduction is performed to relax the Y-ligament.

FIG. 24-C

Fig. 24-C: Internal rotation in abduction with traction. This manoeuvre utilizes the hingelike action of the retinaculum and reduces the fracture.

FIG. 24-D

Fig. 24-D: Reduction has been obtained and secured. Internal rotation is maintained. Adduction tightens the Y-ligament and further consolidates reduction.

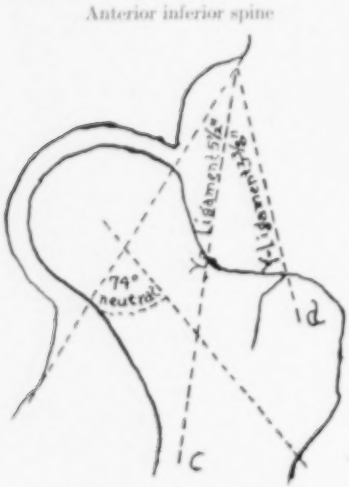
these vessels at the time of fracture doubtless determines whether or not aseptic necrosis will supervene.

REDUCTION OF FRACTURES OF THE FEMORAL NECK

In the light of these experiments and of clinical observations, it is assumed that

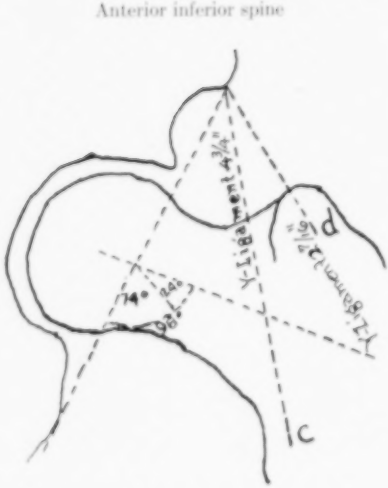
cervical fractures of the femur are produced consistently by the action of the external rotator muscles of the thigh.

Since external rotation of the distal fragment in this fracture is invariably present, it follows that simple internal rotation of the femur should approximate the fracture



Femur in neutral position
Y-ligament legs 5-1/2 " - 3-3/8"

FIG. 25-A



Femur abducted 24°
Y-Ligament legs 4-3/4" - 2-7/16"

FIG. 25-B

Fig. 25-A: Relaxation of the Y-ligament by abduction of the hip. With the femur in the neutral position, the two limbs, *c* and *d*, of the ligament of Bigelow, are in normal physiological tension.

Fig. 25-B: When the thigh is abducted, limbs *c* and *d* of Bigelow's ligament are materially shortened and are relaxed.

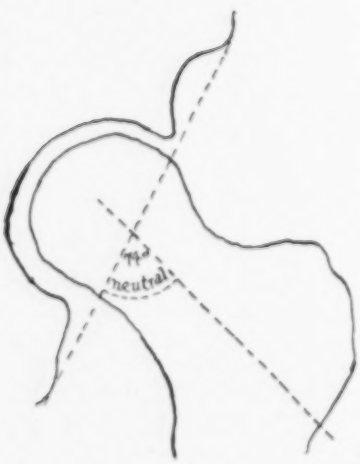
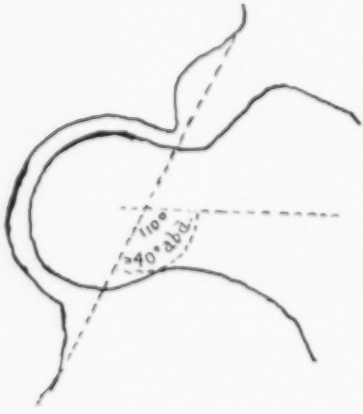


FIG. 26-A



Impingement of neck and acetabulum occurs at 44° abduction with int. rotation of the femur, and at 86° abduction with ext. rotation of the femur.

FIG. 26-B

Fig. 26-A: Femur in neutral position.

Fig. 26-B: Femur in abduction.

As we use external rotation in the manipulation for reduction, it is obvious that impingement of the neck upon the acetabulum does not constitute an element in the reduction.

surfaces. This is indeed the case, and it is made possible by the hingelike action of the retinaculum.

Preceding this manoeuvre of "closing the book", however, it is well to disengage the fracture surfaces which may impinge against one another and may be "locked" due to forward displacement or rotation. This is readily done by increasing the characteristic deformity or "opening the book" wider by maximum manual external rotation and traction (Fig. 24-A).

Then, with the thigh in full external rotation and with the knee flexed, the thigh is abducted as far as possible without force while manual traction is continued (Fig. 24-B). This manoeuvre tightens the hinge or retinaculum, relaxes any muscle pull which may be displacing the distal fragment upward, and relaxes the two legs of the Y-ligament (Bigelow's) (Figs. 25-A and 25-B).

The "book" is now wide open with its surfaces facing each other in full apposition. Impingement of the femoral neck against the acetabulum, if abduction is performed with the limb in external rotation, does not occur and is not an element in reduction (Figs. 26-A and 26-B).

The "book" is then closed by full internal rotation of the femur, in which manoeuvre traction is continued and the bent extremity is used as a crank. The fracture is now reduced (Fig. 24-C). Finally, the thigh is adducted to a position parallel with the long axis of the body, full internal rotation of the thigh and manual traction being constantly maintained (Fig. 24-D). This firmly approximates the fracture surfaces by tightening the Y-ligament and the muscles about the hip.

Any fixation which maintains this full internal rotation will now hold the fracture in place.

In summary, the steps in the manipulative reduction of a fracture of the neck of the femur are:

1. The thigh is externally rotated at the same time as moderate manual traction is applied.
2. The thigh is abducted and external rotation and traction are continued.
3. The thigh in full abduction is internally rotated as manual traction is continued.
4. The thigh is adducted and internal rotation and traction are continued until the limb is parallel with the long axis of the body.
5. Internal rotation is maintained.

NOTE: The author wishes to acknowledge the invaluable aid of Emory D. Roberts, Professor of Civil Engineering, William G. Murphy, Assistant Professor of Civil Engineering, and Emory G. Roberts, Jr., Student, Engineering School, Marquette University.

Photographs and some of the illustrations were done by Mr. Leo C. Massopust, Instructor in Anatomical Art and Director of the Department of Photography, Marquette University School of Medicine.

Preparation for the photograph of the circulation in the foetal retinaculum was done by Percy F. Swindle, Professor and Director of the Department of Physiology, Marquette University School of Medecine.

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EXPERIENCES WITH THE MUSCLE-TRANSPLANT OPERATION FOR THE RELIEF OF PAINFUL ARTHRITIS OF THE HIP

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The relief of painful arthritis of the hip is a difficult problem. This is obvious when one considers the numerous conservative and surgical measures which have been proposed in the literature. Conservative measures have not proved successful and attempts have therefore been made at the surgical relief of this distressing condition. In 1946 Venable and Stuck reported an operation which consisted in transplanting a portion of the vastus lateralis muscle, with its blood supply intact, into a slot cut on the anterior surface of the neck of the femur. They reasoned that, since painful arthritis of the hip was presumably of ischaemic origin, and since animal experiments reported by Stuck and Hinchey in 1944 had shown that the blood supply to the femoral head could be increased, a muscle-flap transplant might be effective in relieving the pain of monarticular arthritis in human patients. The procedure is described in a recent edition of Campbell's Operative Orthopedics, where a suggestion is made that this operation "may be worth a trial".

The procedure described by Venable and Stuck consisted essentially in opening the capsule of the hip and transplanting a flap from the medial half of the vastus lateralis muscle into a slot one by four centimeters, which was cut in the neck of the femur from the base to the trochanteric region. They reported rapid relief of pain and improvement of function in a series of twenty-six out of twenty-seven patients. The relief of pain lasted as long as two years. Roentgenograms made after an operation were reported to have shown an increased proliferation of bone and partial regeneration in the head of the femur.

On the basis of this paper a small series of cases was selected from the Orthopaedic Service of the Out-Patient Department of the Los Angeles County General Hospital from July 1947 to January 1949 and the operation described by Venable and Stuck was tried. This paper presents a review of the results in this series. Many surgeons were involved. Therefore, as may be surmised, various minor deviations from the described technique occurred.

MATERIAL FOR STUDY

Sixteen surgical procedures were performed on fifteen patients during this period. There were seven men and eight women, with an average age slightly above fifty years. The youngest patient was twenty years old and the oldest was seventy-five years old. The etiology of the painful degenerative arthritis was varied and included avascular necrosis following transcervical fracture of the femur, slipped capital femoral epiphysis, congenital dislocation of the hip, malum coxae senilis, osteochondritis dissecans, and traumatic arthritis due to old fractures of the acetabulum. All of the patients have been followed for one year or more, except one who has only been followed for six months. The average follow-up has been slightly less than two years. Nine patients have been followed for two years or more.

RESULTS

Most patients were classified as having poor results (Table I). They experienced no relief of pain after surgery, or else they had relief of pain no longer then four to eight weeks. Three patients subsequently had intra-articular arthrodesis and one finally underwent a Vitallium-cup arthroplasty.

One patient had a good result. This patient had a bilateral Venable-Stuck muscle

TABLE I

RESULTS

Etiology	No. of Cases	End of One Year	End of Two Years	End of Three Years	End of Four Years
Malum coxae senilis	9	5 poor 1 good 3 fair	4 poor 1 good 1 fair	1 poor 1 good	1 good
Congenital dislocation of hip	1	1 poor			
Slipped capital femoral epiphysis	1	1 poor			
Transcervical fracture	2	1 poor 1 poor at 6 mos.	1 poor		
Osteochondritis dissecans	1	1 poor			
Fractured acetabulum	2	2 poor	2 poor	1 poor	1 poor
Total	16	16	9	3	2

transplantation and an adductor tenotomy on one side. The side with the combined procedure had been without pain for one year when the patient was last seen. The side with the transplant alone was improved, although some pain was still present. The patient stated that she was satisfied with the result. Two patients were classified as having satisfactory results because both had stated that they were satisfied with the results of their operations. However, they were not completely relieved of pain. One was satisfied with his result, although he stated that he would submit to another surgical procedure for relief of the pain he felt on walking. Another patient was satisfied with his result one year after surgery, but still had some pain on walking and used a cane.

Roentgenograms made after the operation did not show any improvement in the arthritic process or changes in the head of the femur as reported by Venable and Stuck. Most of the roentgenograms made one year or more after surgery revealed a progression of the arthritic changes. In one patient in whom an arthrodesis was performed, it was found at the second operation that the muscle transplant had a good blood supply and that several large vessels entered the neck of the femur through the slot made during the previous procedure.

DISCUSSION

For physiological reasons one would not expect that an increase in the blood supply to the head of the femur could bring about the reconstruction of a deformed head or of degenerated cartilage of the hip. The results in this small series of cases seem to support the above conclusion. Most patients get relief of pain for a few weeks after this operation, but then the pain begins to return. It is difficult to find an adequate explanation for the relief of pain that these patients experience. It has been suggested that the operation decompresses the head. This is a concept which is difficult to understand and hard to prove. A much more plausible reason, which we would like to advance, is that the rest before and after surgery decreases the pain. The Venable-Stuck muscle transplantation did not result

in sufficient relief of painful symptoms to warrant consideration of this operation in planning the surgical relief of painful osteo-arthritis of the hip in the future.

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Venable, O. S., and Stuck, W. G.: Muscle-Flap Transplant for the Relief of Painful Monarticular Arthritis (Aseptic Necrosis) of the Hip. Ann. Surg., **123**: 641–655, 1946.

DISCUSSION

Tendon Transplantations in Median-Nerve and Ulnar-Nerve Paralysis

(*Continued from page 320*)

Dr. Riordan has given us a good method for obtaining strong tenodesis. Use of the slender split proprius tendons by passing them in front of the transverse metacarpal ligament gives a weaker tenodesis effect. By these methods the tendon has a good angle of approach, namely 35 degrees, the same as a lumbrical muscle, as the tendon passes in front of the transverse metacarpal ligament to the phalanx.

The tenodesis operation fails to furnish voluntary flexion to the metacarpophalangeal joint. The sublimis transfer furnishes this. In some people the long flexor tendons can flex these proximal finger joints — this is seen in some cases of combined median-nerve and ulnar-nerve palsy — but in many this motion is accomplished mainly by the intrinsic muscles, as the long flexors have not a sufficient angle of approach.

In order to give positive voluntary flexion to the proximal finger joint, the tenodesis operation may later be supplemented by a pulley-advancement procedure so that the long flexor can flex this joint. Capsulectomies may also be needed to allow flexion.

A sublimis transfer is a good basic method and is sufficient unless the cock-back is too strong. It may be supplemented by many other procedures.

There are various other ways of holding the proximal joints in slight flexion. The Howard bone block may be used. Free tendon grafts of palmaris longus can be woven through cross holes in proximal phalanges, across the front of the joint, and over the back of the metacarpal, passing on to each joint in turn, or they may be used as separate grafts to each joint in turn, each being anchored to a drill hole across the metacarpal. Arthrodeses of either the proximal or middle finger joints may be necessary for extreme claw-hand. Arthrodesis of either joint improves the motion of the other joint. Still another method of stabilizing the proximal joint in flexion is to create the "intrinsic-plus" condition by the use of an escharotic to bring about fibrosis in the interosseus muscle.

Just as the normal interosseus muscle needs stabilization of the proximal joint in extension to extend the distal two joints, so the long extensor needs stabilization of the proximal joint in flexion to extend the distal two joints.

It would seem that in cases with straight or moderately cocked proximal joints the sublimis transfer gives good results, but in those with strong cock-back and long-lasting deformity the tenodesis procedure or some method of stabilizing the proximal finger joint in slight flexion, perhaps supplemented with a pulley-advancement procedure, will be advisable.

I wish to thank Dr. Riordan for emphasizing this tenodesis principle. It certainly has a place in our armamentarium.

HORIZONTAL LATERAL ROENTGENOGRAPHY OF THE HIP IN CHILDREN

A Preliminary Report*

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The orthodox or routine roentgenographic examination of the hip usually comprises the anteroposterior view and the lateral view made with the patient in the "frog-leg"

FIG. 1

Anteroposterior (upper) and lateral ("frog-leg" position) (lower) x-rays showing that the pelvic landmarks are identical in each.

* Based on an exhibit at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 1952.

FIG. 2-A

Photograph of the pelvis with the femur extended in the horizontal lateral position.

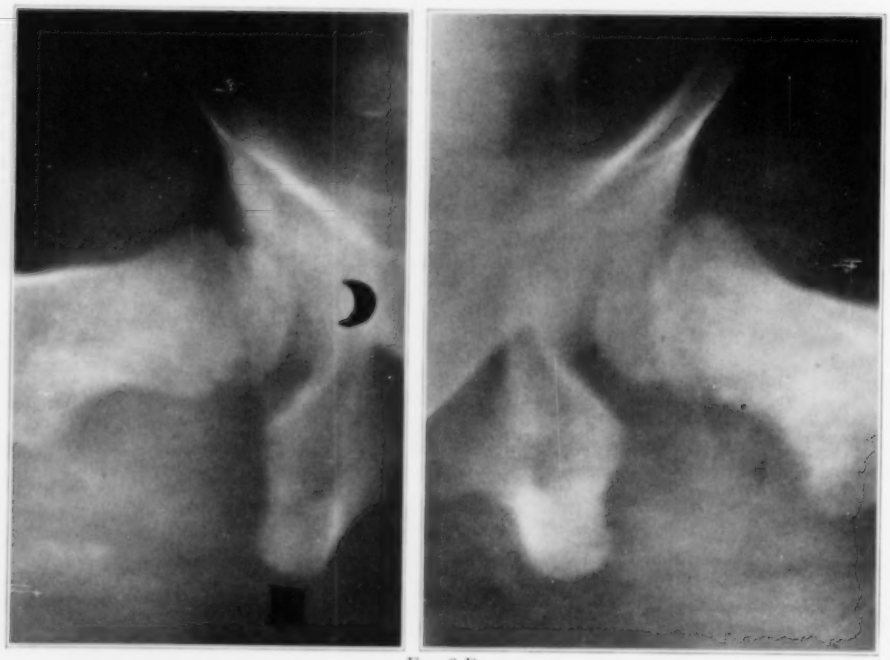


FIG. 2-B

Horizontal lateral x-ray of the pelvis shows that the pelvic landmarks have changed.

position. This constitutes a complete examination of the head and neck of the femur only. It is not a complete examination of the hip joint, since the landmarks of the pelvic component are identical in each view (Fig. 1). In the horizontal lateral view, a totally different plane of the pelvis, as well as a second plane of the head and neck of the femur, is examined. The combination of the anteroposterior and horizontal lateral views is a more complete examination of the hip joint, since this combination is in accord with the roentgenographic principle that bones and joints should be examined in at least two planes.

The difficulty of determining when reduction of a congenital dislocation of the hip has been obtained led to the use of the horizontal lateral view in conjunction with the anteroposterior view and the lateral view made with the patient in the "frog-leg" position (Figs. 2-A and 2-B).

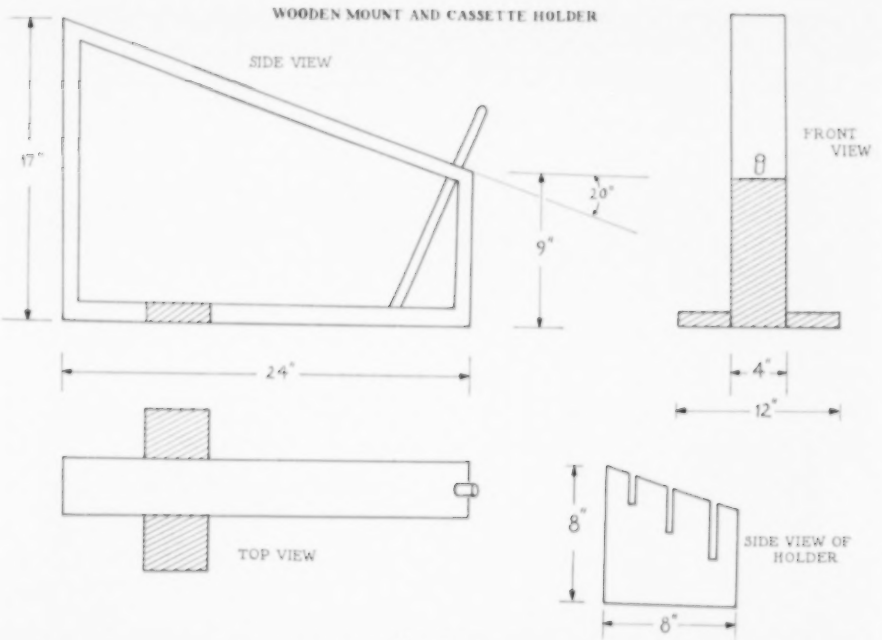


FIG. 3-A

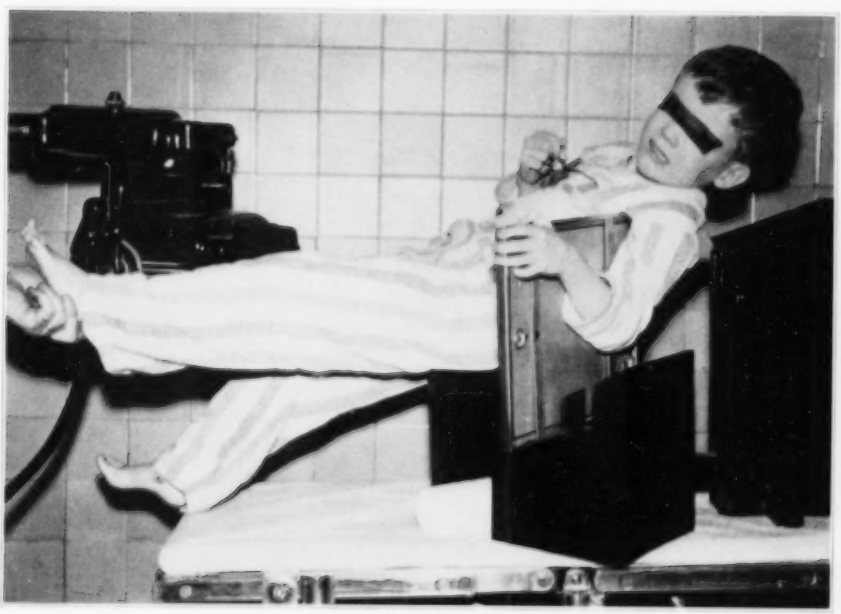


FIG. 3-B

Photograph of a patient in position on the apparatus.

EQUIPMENT

In the making of the horizontal lateral roentgenogram of a child's hip, two simple pieces of equipment have been found helpful. The first is a mount. This is a four-inch board mounted at a 20-degree angle. A pubic post is set in the lower end. The lower end is but ten

FIG. 4-A

FIG. 4-B

Figs. 4-A and 4-B: Anteroposterior (Fig. 4-A) and lateral ("frog-leg" position) (Fig. 4-B) x-rays of a superior and lateral dislocation.

FIG. 4-C

X-ray made following treatment.

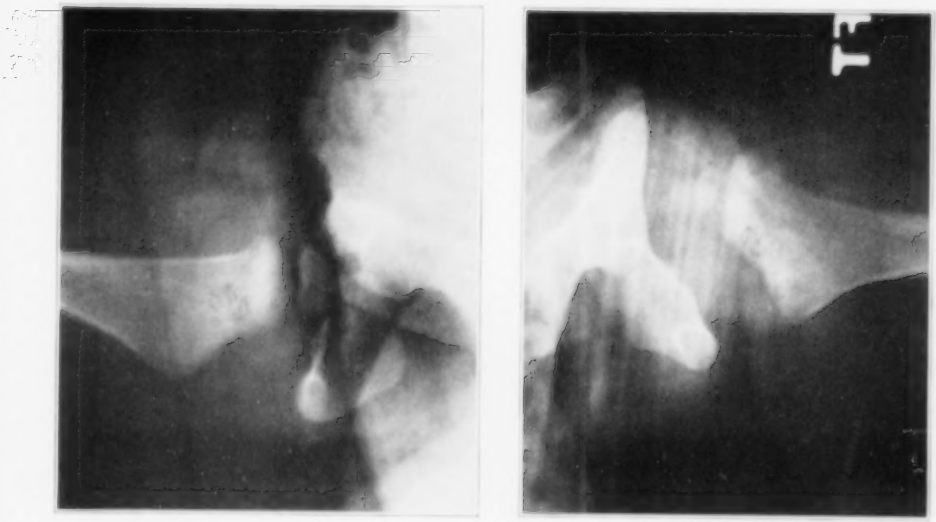


FIG. 4-D

Horizontal lateral x-rays of both hips. The left hip is slightly anterior to the acetabulum.

inches from the top of the table, while the upper or cephalad end is seventeen inches from the table (Fig. 3-A). The second piece of equipment is a slotted box designed to hold the cassette. The Lysholm grid cassette of Dr. Camp is regularly used.[3]

METHOD OF POSITIONING

The child is lifted to straddle the mount and a wide elastic-type bandage is wrapped about his trunk and the top board. When the pelvis is symmetrical on the mount, the pubis should abut the pubic post.

The extremity on the side to be examined is elevated; with the great toe pointing at a right angle to the floor the extremity is placed parallel with the floor. The extremity is abducted to about 20 degrees.

The cassette is put on end in the holder and is placed either in the axilla or superior to the ilium (Fig. 3-B). Either position is satisfactory.

The x-ray beam is turned in a horizontal direction and is aimed through the acetabu-

FIG. 5-A

Anteroposterior x-ray of congenital dislocation of the left hip.

FIG. 5-B

Routine anteroposterior x-ray made after treatment of dislocation of the left hip.

FIG. 5-C

Routine lateral x-ray ("frog-leg" position) made after treatment of the dislocation of the left hip.

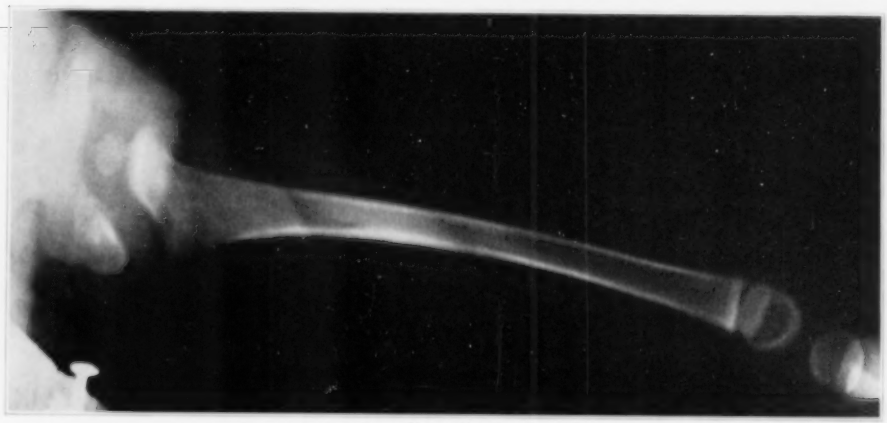


FIG. 5-D

Horizontal lateral x-ray shows no anterior or posterior dislocation.

lum at right angles to the cassette. This does not differ from the standard roentgenographic methods used in hip nailing in the operating room. Rapid exposure will give greater detail.

To demonstrate the value of the horizontal lateral view, several representative cases are presented. Figures 4-A and 4-B are anteroposterior and lateral ("frog-leg" position) views showing a dislocation of the hip. Figure 4-C is an anteroposterior roentgenogram made later in the course of treatment. The head of the femur lies approximately at the level of the acetabulum, but it is impossible to make any further statement as to its relationship to the joint from these views. The head may have been reduced anteriorly or posteriorly to the acetabulum.

Figure 4-D is a horizontal lateral view taken at the same time as Figure 4-C, and it reveals that the head lies closely to the anterior spine. Since it is not superior in the other views, it must be anterior to the acetabulum.

Figure 5-A shows an obvious dislocation. As shown in the roentgenogram, the head of the left femur is superior and lateral to the acetabulum. After an interval of therapy,

FIG. 6-A

Superior dislocation had been reduced on the right. Lateral displacement was unchanged. The left hip was completely dislocated.

FIG. 6-B

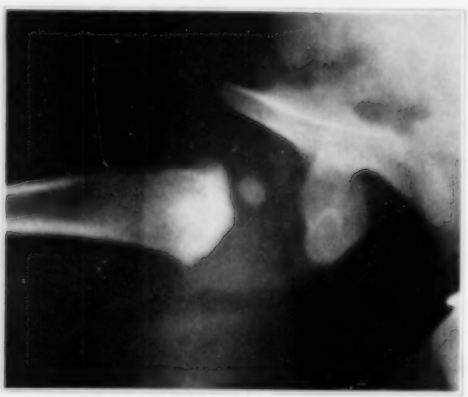


FIG. 6-C

Fig. 6-B: Definite anterior dislocation is shown in the x-ray.
Fig. 6-C: Internal rotation of the femur corrected the deformity seen in Fig. 6-B.

routine views were again made. Because of the factor of the two-plane relationship, reduction was uncertain. Figure 5-C, the horizontal lateral view, reviewed in conjunction with Figure 5-B, proved the head to have been reduced.

A difficult case of bilateral congenitally dislocated hip is shown in Figure 6-A, in which the right hip had been manipulated so that a previous superior dislocation was reduced. In this routine view only slight lateral displacement is seen. The question arises whether the femoral head is anterior or posterior to the acetabulum or in the acetabulum. No result can be determined from the routine views. In Figure 6-B, however,—the horizontal lateral view—definite anterior subluxation is seen. After further forced internal rotation, a roentgenogram (Fig. 6-C) demonstrated correction to have been improved.

The anatomical landmarks are clearly seen in Figures 7-A and 7-B. The routine anteroposterior film shows the anterior superior iliac spine (*A*), the ischial tuberosity (*B*), the acetabulum (*C*), and the femoral head (*D*). In Figure 7-A a superior and inferior plane is appreciated; in Figure 7-B we can determine an anterior or posterior plane of the complete hip.

In order to prove that we have obtained true lateral views of femora by means of the method described, we have, where possible, included the condyles of both femora. When

FIG. 7-A

Anteroposterior x-ray: *A*, anterior superior spine; *B*, ischial tuberosity; *C*, acetabulum; *D*, femoral head.

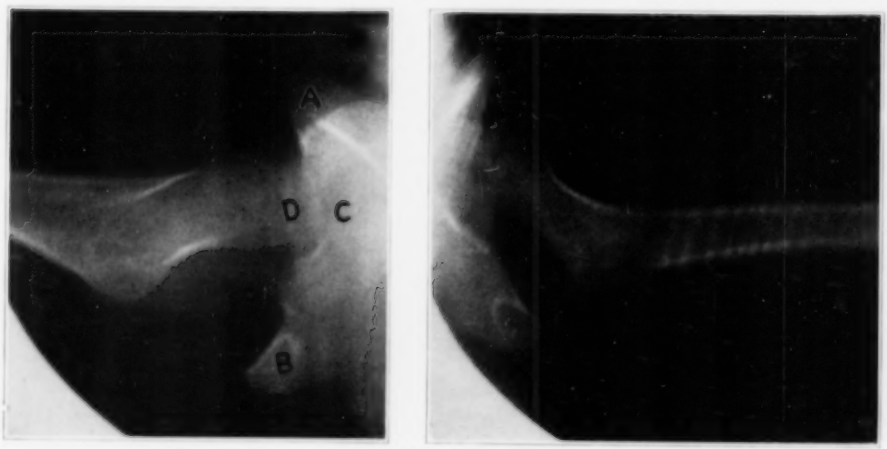


FIG. 7-B

Horizontal lateral x-ray: *A*, anterior superior spine; *B*, ischial tuberosity; *C*, acetabulum; *D*, femoral head. Same patient as shown in Fig. 7-A.

FIG. 8-A

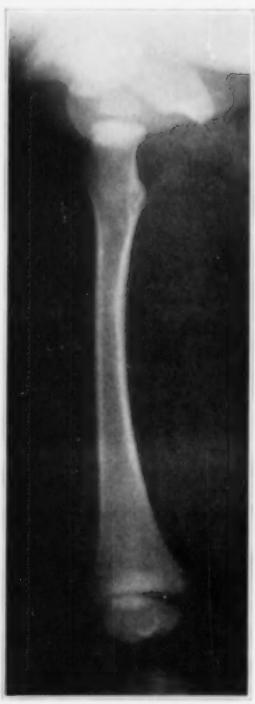
Horizontal lateral x-ray; note condylar superimposition.

FIG. 8-B

Horizontal lateral x-ray; external rotation of the thigh.

FIG. 8-C

Horizontal lateral x-ray; internal rotation of the thigh.



these are superimposed, barring any femoral torsion, the projected angle of anteversion should appear at the neck.

Figure 8-A was made according to the prescribed method with the great toe pointing at a right angle to the floor and the leg parallel with the floor. Complete superimposition of the condyles occurs. Figure 8-B demonstrates the results when the leg is externally rotated to 90 degrees, and Figure 8-C exemplifies the changes when the leg is internally rotated to 90 degrees. If the method is applied correctly, the results previously described will follow. The relationship of the femoral head to the acetabulum in all degrees of rotation does not vary, but the application of horizontal lateral views to the therapy of congenitally dislocated hips should prove useful.

TECHNICAL CONSIDERATIONS

Because we are adding the making of additional x-ray views to the examination of the hip in the child, roentgenological safety should be a consideration. The child is exposed to no more radiation in the making of this view than in the making of any of the routine views. However, it has been our experience that, in attempting to attain high-quality films, several additional films will be taken. We, therefore, have arbitrarily established the period of a week or its equivalent of rest per horizontal lateral film. Thus, if four exposures in the horizontal lateral position are made, then a waiting period of four weeks should ensue. There is no more danger of incurring sterility or a local radiation reaction from this method than from standard procedures.

COMMENT

It has been our experience that horizontal lateral roentgenograms provide an invaluable tool in the management of congenital dislocation of the hip. The view is one in which the anterior-posterior relationship of the head and the acetabulum may be seen. The method is not an innovation; it has been used frequently in the operating room to determine when a guide wire for the Smith-Petersen nail has been properly inserted, and it has been amply illustrated by Bridgman. The change we have suggested is the use of a board inclined to 20 degrees so that the pelvis is tilted anteriorly and the acetabulum lies mid-way between landmarks which can always be seen. The view can be obtained without the use of the board, but the resulting films are more difficult to interpret.

This method may have another valuable function. The angular measurement of the anteversion of the neck of the femur can be calculated from this view. The necessity for rotational osteotomies can be determined quite simply by means of repeated x-ray examinations in which this technique is used.

Entities other than congenital dislocation have been examined roentgenographically by means of this technique. The volume of data collected at present is too small to have any statistical validity, but it has been an impression that anteversion of the neck of the femur is increased in Legg-Perthes disease and slipped capital femoral epiphysis.

The authenticity of these preliminary observations can be determined only after a large series has been examined. The relationship of anteversion to either of these may be of some significance or may be merely a concomitant unrelated observation.

CONCLUSIONS

1. The anteroposterior view and the lateral view made with the patient in the "frog-leg" position are not a complete examination of the hip joint.

2. Horizontal lateral roentgenograms of the hip in children, in conjunction with other views, offer a more comprehensive method of investigation in the diagnosis and treatment of pathological conditions of the hip.

3. While no statistically valid data may be drawn from the present small volume of work, interesting observations have been made in roentgenography of congenital

dislocation of the hip, Legg-Perthes disease, and slipped capital femoral epiphysis.

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CONGENITAL ABSENCE OF THE SACRUM AND COCCYX

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Agenesis of the terminal segments of the spinal column has been reported as a relatively infrequent occurrence [15]. The failure of development may vary from mere absence of the lower coccygeal segment to complete non-existence of vertebrae below the

Fig. 1-A

Fig. 1-B

Fig. 1-C

Fig. 1-A: This photograph illustrates the narrowed pelvis and tapered lower extremities which characterized the patient. The club-foot on the left is also demonstrated.

Fig. 1-B: Viewed from the back, the patient presented a shortened neck, elevation of the shoulders, narrowed waist, shortened intergluteal fold, and tapered lower extremities. The posterior prominence of the lower portion of the trunk is suggested but not clearly visible in this photograph.

Fig. 1-C: When the patient was placed in the sitting position, the lumbar kyphos was clearly shown.

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FIG. 2-A

FIG. 2-B

Fig. 2-A: The anteroposterior roentgenogram of the thoracolumbar spine indicates the abrupt termination of the spinal column at the fourth lumbar vertebra. This vertebra exhibits imperfect formation of the transverse processes. Note the approximation of the iliac wings superiorly and of the pubes and ischia inferiorly. The hemivertebrae in the thoracic spine, diminution of the ribs on the right side of the thorax, and the mild scoliosis are also evident.

Fig. 2-B: The lateral view of the spine confirms the absence of the sacrococcygeal segment.

tenth thoracic segment. The more extreme degrees of involvement are often incompatible with life and have been described in reports on stillbirths. The lesser degrees of spinal change—for example, absence of the lower coccygeal elements—in great part go unnoticed and are often recognized fortuitously during unrelated roentgenographic studies. Because of this broad range of possible spinal irregularities, the recorded case presentations do not precisely depict the true incidence of this condition. In a recent survey[6] which listed forty-five as the total number of reported cases showing absence of part or all of the sacrum, probably only those of intermediate severity were included. The case to be presented is an example of absence of the spine below the fourth lumbar vertebra and certain associated neurological sequelae, as well as other skeletal anomalies.

J. R., born on April 23, 1946, at a full-term breech delivery, was the fourth child in a normal family. His mother had had one miscarriage at four months following her second pregnancy. She could recall no illness or other untoward circumstance during her pregnancy with the patient. The child had been incontinent of urine and faeces from early childhood. He had had two previous hospitalizations, the most recent one for the conservative correction of a club-foot deformity on the left.

The patient was admitted to the Hospital on March 25, 1952. Physical examination revealed a boy

FIG. 3

FIG. 4

Fig. 3: In this roentgenogram, hemivertebrae in the thoracic spine are again demonstrated, as well as the cervical spina bifida.

Fig. 4: Anteroposterior roentgenogram of the feet, showing the prominent club-foot deformity on the left.

with a suggestive barrel-chest, shortened neck, and disproportionately shortened trunk (Figs. 1-A and 1-B). His upper extremities were normal. The lower extremities were held in an attitude of moderate external rotation with flexion at the hips and knees. Walking independently was possible but was accomplished awkwardly, insecurely, and with a left-sided limp. There was a prominent kyphos at the lower lumbar level which was especially evident in the sitting position (Fig. 1-C). There was a mild left thoracic, right lumbar scoliosis. Palpation revealed that the lumbar spine ended abruptly with no detectable sacrococcygeal mass. The pelvis was narrowed, the buttocks were small, and the intergluteal fold was shortened.

There was characteristic tapering of the lower extremities, more on the left, since the muscle development was greater in the thighs than in the calves. A rigid equinovarus deformity of the left foot and 40 degrees of internal torsion of the left tibia were present. The right foot appeared normal except for a flexed distal phalanx of the great toe, and there was a 10-degree internal torsion of the right tibia. The atrophy of both calves was striking; it was greater on the left than on the right. The muscle power of the hips and knees was fair to good bilaterally. There was active plantar flexion of the right foot and toes, but no active dorsiflexion. There was neither active nor passive dorsiflexion or plantar flexion in the left foot and ankle.

Both hips exhibited complete absence of internal rotation. There were 10-degree flexion contractures of both knees. The right ankle had a passive range from 90 to 110 degrees; the left ankle was fixed at 120 degrees of equinus. The deep reflexes were hypo-active. There was slight hypo-aesthesia of both lower extremities, but pain perception was definitely present.

Roentgenographic studies revealed complete absence of the fifth lumbar vertebra, the sacrum, and the coccyx. The fourth lumbar vertebra, forming the most dependent portion of the spinal column, exhibited rudimentary development of its transverse processes. The iliac wings were almost entirely approximated posteriorly; this contributed to the narrowing of the pelvis. The hips appeared to be normal. Both the pubes and the ischia were quite close together (Figs. 2-A and 2-B).

There was a moderate left cervicothoracic and a right thoracolumbar scoliosis. Two hemivertebrae in the thoracic spine were noted. There were ten ribs on the right, the missing ribs corresponding to the absent halves of the thoracic vertebrae, and the normal number of ribs on the left. There were multiple spina bifida formations in the cervical spine (Fig. 3). The scapulae were elevated, the left more than the right. Significant equinovarus deformity of the bones of the left foot and ankle was evident (Fig. 4).

DISCUSSION

Etiology

The theories advanced have ascribed the condition to vague factors believed to produce caudal suppression by minute embryonal trauma [7], by varying degrees of defects in the posterior portions of the metameric segments [5], and by "interference with a primary organizer" during the early stages of foetal development [6].

It has been demonstrated by animal experimentation that chickens with absence of sacrocaudal vertebrae resulted when the developing embryo was exposed to high tempera-

tures [2]; suppression of the notochord followed exposure to lithium salts [11]; pigs without hind limbs developed from sows fed diets deficient in vitamin A [16]. The consensus has been that, whatever the noxious agent, it must have exerted its deleterious influence early in embryonal development. In a recent piece of experimental work, one investigator induced skeletal abnormalities in developing chicks by the injection of insulin into the embryo [4]. He was able to produce spinal defects resembling spina bifida, with partial or complete suppression of development of some of the vertebrae, as well as other skeletal limb abnormalities. The insulin injections made in the first two days of incubation were most frequently followed by vertebral changes, whereas other skeletal aberrations resulted from later injection, indicating that the part most affected was that which was in the most active stage of development or differentiation at the time of the injection.

In addition to maternal nutritional deficiencies, other extrinsic factors believed to be significant in the production of anomalous foetal development are those following roentgen irradiation and infectious diseases contracted by the mother in the early stages of pregnancy. Rubella has been definitely incriminated [8] and other infectious diseases may similarly be involved, although it has been suggested that, in cases of severe infections, the pregnancy might terminate in abortion or miscarriage. As for the importance of inheritable genetic factors, a single instance of congenital absence occurring in father and son has previously been reported [13].

Clinical Features

The appearance of the patients depends on the extent of spinal involvement and the degree of associated changes of a neurological or skeletal character. The clinical features of a given case usually depend in part on whether the sacrococcyx is totally or partially absent. In cases in which the sacrum is not present and the iliac bones meet posteriorly in the mid-line, there is flattening of the buttocks, shortening of the intergluteal fold, loss of the sacrococcygeal prominence externally, and diminution of the transverse diameter of the pelvis.

The other prominent factor in determining the appearance of a patient is the concomitant neurological involvement. In addition to the urinary and fecal incontinence commonly present, there are atrophy and diminution of muscle power of the lower extremities together with variable deformities of the feet. Because of the atrophy, occurring especially in the legs, a cone-shaped appearance of the lower half of the body develops. In the extreme case this has merited the designation of "siren" or mermaid configuration. In the survey article of forty-five recorded cases already mentioned[6], twenty-one instances of club-foot were distributed in patients exhibiting vertebral absences as far down as and including the second sacral segment. All cases exhibited degrees of muscle wasting. There were eight known instances of hip dislocation in cases of involvement at levels including the first sacral segment. There were twenty-two cases of urinary incontinence, three of these in patients too young for incontinence to be significant, eight cases of total fecal incontinence, five of partial fecal incontinence, and two cases occurring in patients too young for incontinence to be significant; all these were concomitant with involvement at levels down to the fourth sacral segment.

In addition to those mentioned, many other unusual associated developmental anomalies have been recorded. These have included total absence of one lower limb [5], suppression of neural elements [7], hemivertebrae [1], spina bifida [10], myelomeningocele [12], fusion of adjacent ribs [5], articulation of opposite ribs in the mid-line where corresponding vertebrae are absent [14], diminution in numbers of ribs, scoliosis [15], and anorectal abnormalities [5].

SUMMARY

The patient here reported presented multiple skeletal abnormalities indicating diffuse adverse influences brought to bear principally on the developing spinal column. The

absence of two ribs on one side coincided with the absent halves of the thoracic vertebrae, thus indicating the "intimacy of the primordium of a rib and its corresponding vertebra" [2].

The clinical appearance of tapered lower extremities, as well as the unilateral club-foot and rectal and urinary incontinence, coincided with the experience recorded in previous papers. The narrowed pelvis, flattened buttocks, and shortened intergluteal fold were natural sequelae of total absence of the sacrum.

Despite the extensive skeletal changes, this child was able to sit and walk, although walking was materially compromised by the rigid deformity of the left foot. At present, suitable conservative orthopaedic measures are again being directed toward correcting the recurrent and difficult foot deformity.

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CHORDOMA OF LUMBAR VERTEBRA

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Chordoma is a slow-growing malignant tumor which arises from elements of the primitive notochord. It was first described by von Luschka in 1856. Later Müller, Ribbert, and others established the relationship of the tumor to primitive notochordal tissue. Horowitz in 1941 called attention to the fact that chordomata arise more often in heterotopic chordal vestiges than in the normal remnant of the notochord, the nucleus pulposus.

Over 300 cases of chordoma have been reported. The lesion most commonly arises in the sacrococcygeal region. A clinical pathological study of these lesions, as well as a review of the literature, was made by Gentil and Coley in 1948. Cranial chordomata are next in frequency. These usually arise in the sphenoid or the spheno-occipital region; more rarely they are found in the nasopharynx, the maxilla, the mandible, and even in the larynx. Cranial chordomata have been recently collected and reviewed by Tollefsen, Groesbeck, and Holleb.

Chordomata arising in the vertebral region are the least common, comprising less than 15 per cent. of the known cases. The first authentic case of a vertebral chordoma was described by Raul and Diss in 1924. In their review of the literature in 1944, Faust, Gilmore, and Mudgett collected thirty-four such cases. Thirteen other vertebral chordomata have since been reported, making a total of forty-seven cases.

The vertebral lesions occur most often in the lumbar region, but all parts of the vertebral column have served as primary sites. Like chordomata elsewhere, those arising in the vertebrae are slow-growing with an insidious onset of dull pain. Pressure symptoms related to spinal nerves or the cord itself finally compel the patient to seek medical attention. Positive neurological findings due to compression of the cord or nerve-root compression may or may not be present. A palpable mass, often present in chordomata of the sacrococcygeal region, is seldom found.

The roentgenographic appearance of vertebral chordomata is predominantly one of bone destruction. There may, however, be an associated osteoblastic reaction. Characteristically there is involvement of adjacent vertebrae with destruction of the arch as well as of the body and final collapse. Dyke feels that the involvement of several adjacent vertebrae is more common in chordoma than in any other malignant tumor.

The course of chordomata of the vertebral region, like that of chordomata elsewhere, is slowly progressive, with a fatal termination usually within six years. Chordomata of the vertebrae are not so prone to metastasize as those of the sacrococcygeal region, but they have been known to do so. In the case of chordoma of the lumbar spine reported by Morris and Rabinovitch, there were metastases to the brain, lungs, pancreas, skull, thoracic vertebrae, and to the axillary and iliac lymph nodes.

The results of treatment of vertebral chordomata have been less encouraging than those of the sacrococcygeal region. In the latter site, resection of the tumor has been successfully performed by Coley, Higinbotham, and others. Complete surgical excision of vertebral lesions has been impossible. Worth-while relief from pressure symptoms, however, has been achieved by laminectomy and partial resection. The results of roentgen therapy have been discouraging, although symptoms are occasionally relieved temporarily.

The following new case of a proved vertebral chordoma with palliative treatment successful to date is reported:

CASE REPORT

Dr. T. M. (Case No. 11038) a dentist, thirty-nine years old, was admitted to the Bone Tumor Service on November 5, 1951, with the chief complaint of low-back pain.

The patient gave a history of a back injury and fracture of the scapula, incurred in an automobile accident while he was in the armed forces in 1943. Following recovery from this, he had no symptoms referable to his back until April 1951, when he had an episode of dull continuous low-back pain lasting ten days and subsiding without treatment. In September 1951, while he was bending to reach for an object, a sudden severe pain developed in the mid-lumbar region, radiating into the right thigh and knee. The pain persisted in spite of bed rest and the patient was admitted to his community hospital with a provisional diagnosis of herniated intervertebral disc. He was treated for ten days by traction on the right lower extremity, followed by application of a plaster jacket. These measures relieved the back pain only slightly; the radiation of pain localized in the right buttock. The patient then remained in bed for six weeks without relief of his symptoms. Roentgenographic studies of the spine were suggestive of a destructive lesion of a lumbar vertebra and he was admitted to Memorial Hospital. There had been a weight loss of twenty pounds during the present illness.

Physical examination revealed a well developed white male in moderate distress because of low-back pain. Significant physical findings were confined to the back and lower extremities. There was straightening of the normal lumbar curve with spasm of the paravertebral muscles. There was no localized tenderness of the spine or buttocks; no tumor mass was present. Straight-leg raising on the left was normal; on the right it was limited by marked lumbar pain. There was no muscle atrophy of the lower extremities and no sensory loss. There was slight diminution of the deep tendon reflexes on the right.

Laboratory examination revealed no abnormalities in the cellular elements of the peripheral blood or of the sternal marrow. Urinalysis was normal. The plasma protein was 7.0 grams per 100 cubic centimeters, the serum calcium 10.2 milligrams per 100 cubic centimeters, the serum alkaline phosphatase 4.3 Bodansky units and the acid phosphatase 0.44 Bodansky units.

Roentgenographic studies of the chest revealed no abnormalities. An excretory urogram revealed a bifid renal pelvis on the left but was otherwise normal. Films of the lumbar portion of the spine (Figs. 1 and 2) revealed an irregular area of bone destruction involving the posterior two thirds of the body of the third lumbar vertebra. The destruction extended into both pedicles, particularly the right, with a slight degree of compression of the vertebra posteriorly. There was also involvement of the superior and inferior articular processes with extension to the inferior articular processes of the second lumbar vertebra. Examination of the remainder of the spine disclosed an area of diffuse sclerosis in the posterior part of the body of the sixth thoracic vertebra; this was believed to be unrelated to the process in the lumbar region.

An aspiration biopsy of the third lumbar vertebra was performed soon after admission. This was re-

FIG. 1

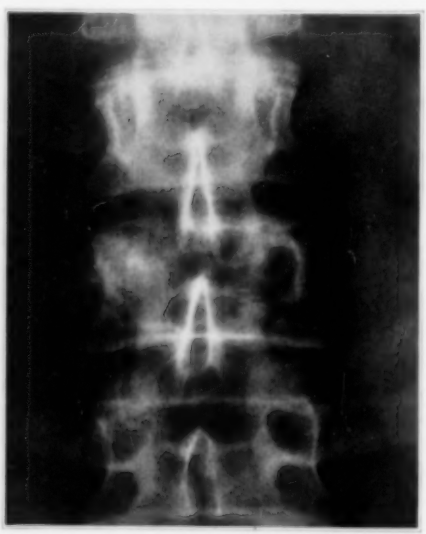

FIG. 2

Fig. 1: Chordoma of the third lumbar vertebra, lateral view. Note the destructive nature of the lesion which is most marked in the posterior two thirds of the body and in the pedicle.

Fig. 2: Chordoma of the third lumbar vertebra, anteroposterior view. The destructive lesion is less readily recognized than in the lateral view and illustrates the necessity of obtaining roentgenograms in both projections in every case of suspected involvement of a vertebra.

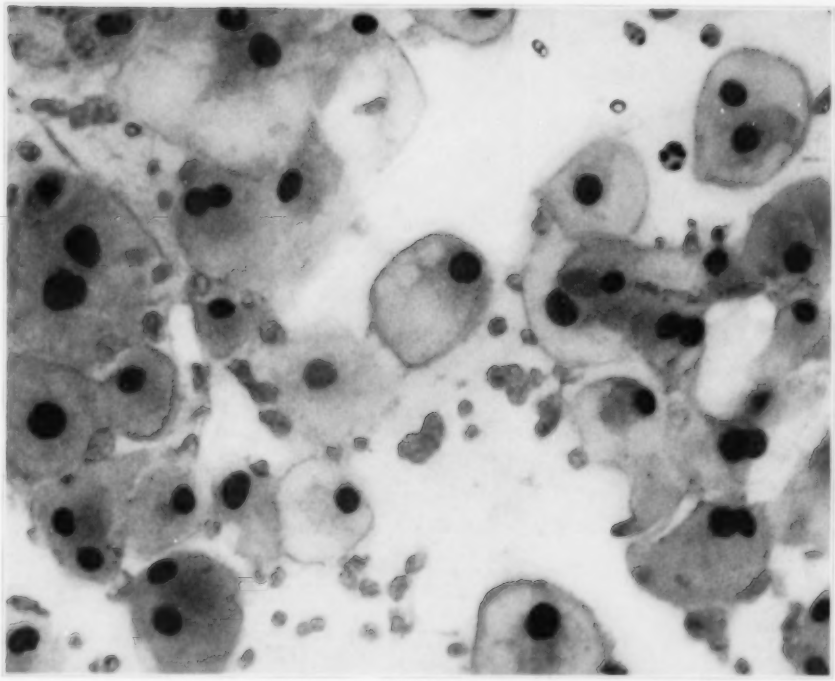

FIG. 3

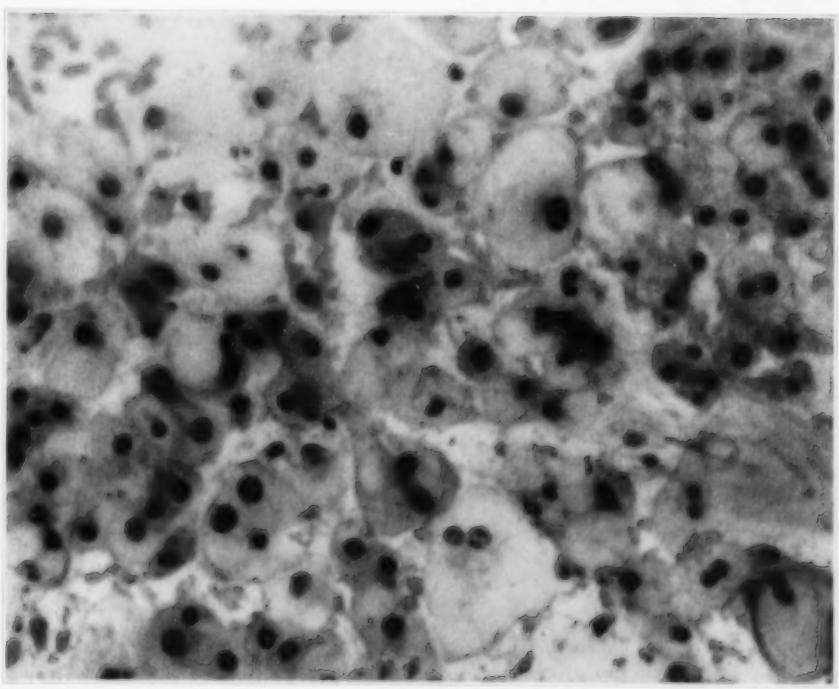

FIG. 4

Smears of vertebral chordoma, showing characteristic cells with loculated cytoplasmic mucin and generally eccentric, small, moderately hyperchromatic regular nuclei. (Fixed in air and stained with hematoxylin and eosin. Magnified × 550.)

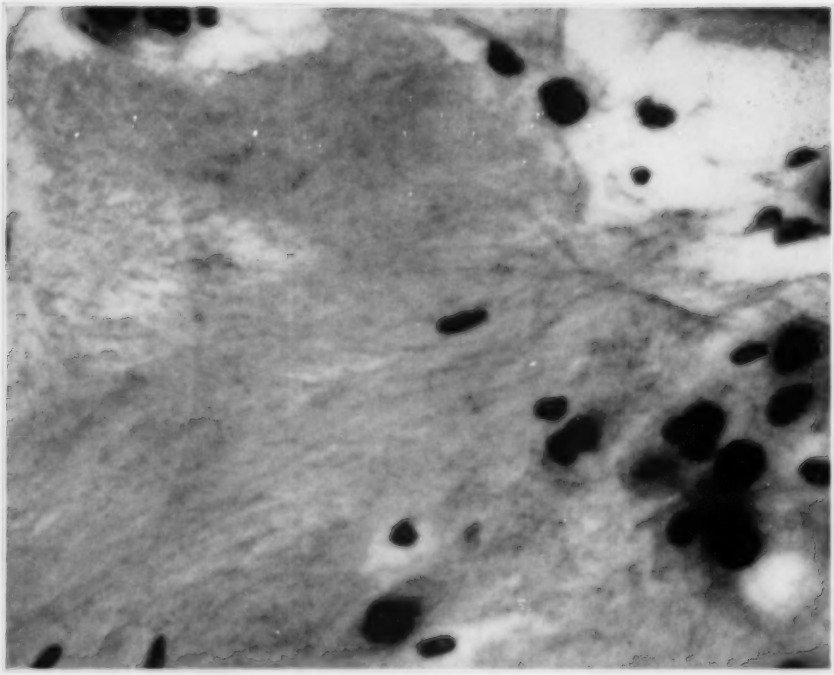

FIG. 5

Smear of chordoma illustrating stringy abundant mucin with isolated chordoma cells. (Hematoxylin and eosin stain; × 550.)

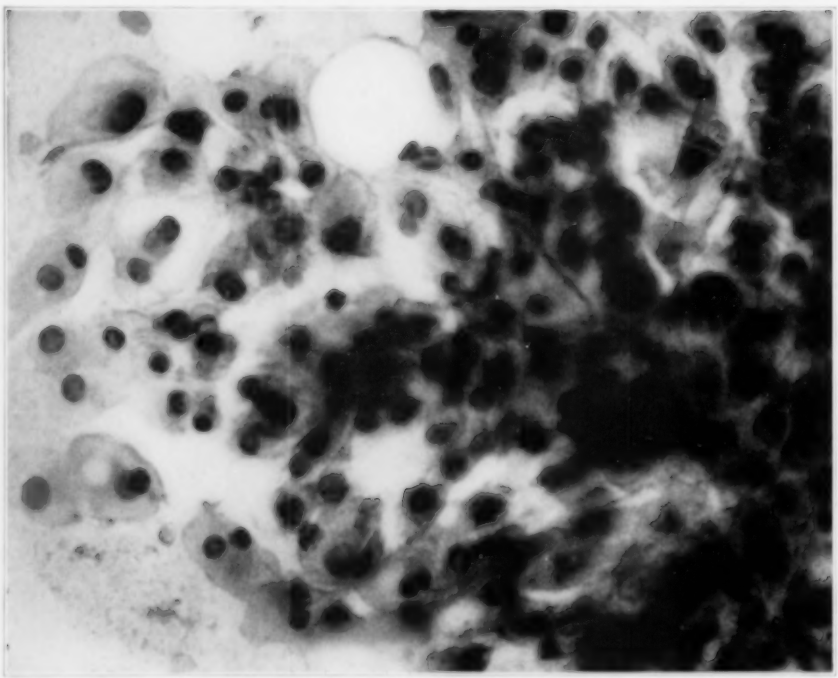

FIG. 6

Smear of chordoma illustrating one of the numerous cellular foci. (Hematoxylin and eosin stain; × 550.)

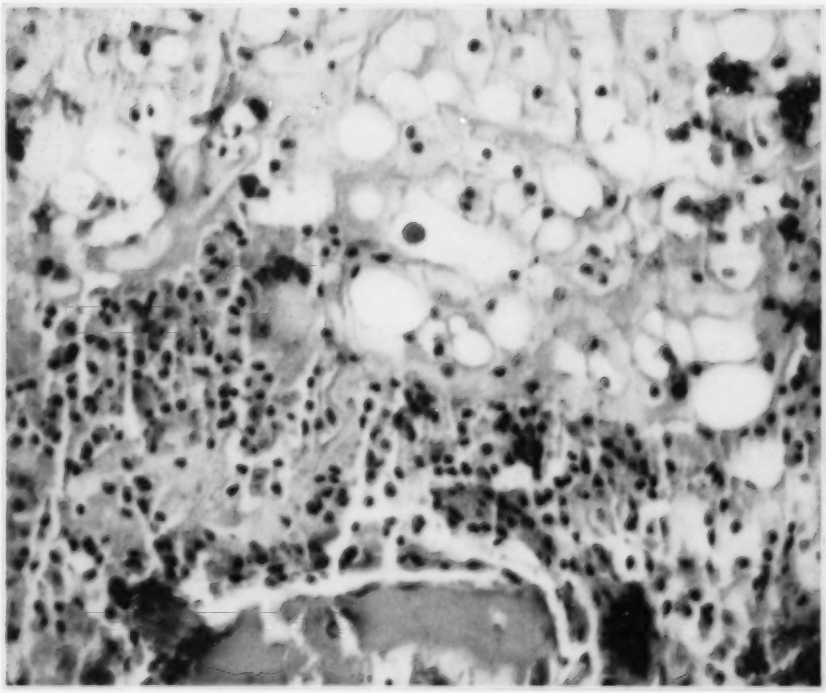

FIG. 7

Paraffin section of a fragment of chordoma removed from lumbar vertebra, showing the typically vacuolated cells. A bone trabecula is seen at the bottom of the photomicrograph. (Hematoxylin and eosin stain; × 225.)

ported to show only blood and calcified débris. On November 14, 1951, an exploration and open biopsy of the lumbar spine was performed under general anaesthesia. The preoperative diagnosis was metastatic cancer, primary site undetermined. At operation a diffuse area of softening and bone destruction was encountered in

FIG. 8

FIG. 9

Fig. 8: Lateral roentgenogram of lumbar vertebrae, made in September 1952, ten months after therapy. There is some evidence of bone repair and there has been no extension of the destructive process.

Fig. 9: Anteroposterior roentgenogram of lumbar vertebrae, made in September 1952, showing no signs of renewed activity of the lesion.

the lamina of the third lumbar vertebra. The bone was replaced by a poorly circumscribed mass of soft, rather gelatinous material, brick red in color. An immediately air-fixed smear of the specimen stained with hematoxylin and eosin (Figs. 3 and 4) was diagnosed as chordoma by Dr. Arthur C. Allen of the Pathology Department.

Histological examination of the excised material revealed findings confirmatory of the initial examination. There were tiny fragments of bone, surrounded by tumor cells growing both in sheets and in small clumps. The cells were large and rounded, with a finely granular, pale cytoplasm and small, regular, hyperchromatic nuclei. Mitotic figures were few in number. A striking feature was abundant intracellular and extracellular mucin, demonstrated by the usual preparations and by periodic acid Schiff stains. The microscopic appearance was typical of that of chordoma (Figs. 5, 6, and 7).

Following operation, the patient was fitted with a spinal brace which allowed him to become ambulatory, and x-ray therapy was started. Treatment was begun directly over the third lumbar vertebra with the following factors: 10-by-10 centimeters portal, 250 kilovolts, 30 milliamperes, 1.5 millimeters copper filter, 50 centimeters target skin distance. A tumor dose of 1560 roentgens was given in two weeks. The therapy was then continued on the million-volt machine: 10-by-10 centimeters anterior portal and two 10-by-8 centimeters posterior oblique portals, 3 milliamperes, 3.8 millimeters lead filter, 70 centimeters target skin distance. A total tumor dose of 3940 roentgens was delivered to the third lumbar vertebra in slightly less than one month.

Within a month after completion of the radiation therapy, the patient was symptomatically improved. By April 1952 he had regained five pounds in weight; roentgenograms revealed no extension of the destructive process in the lumbar portion of the spine. In May 1952 he was symptom-free except for a tired sensation in the lumbar region after standing for long periods. He continued to wear the spinal brace.

The patient has been followed regularly in the Bone Tumor Clinic and has shown continued improvement. By September 1952 he had gained thirty pounds. Physical examination disclosed no abnormalities. Roentgenographic examination of the lumbar portion of the spine disclosed no evidence of activity of the disease (Figs. 8 and 9).

NOTE: The authors wish to thank Dr. Arthur C. Allen of the Pathology Department, Memorial Hospital, for his aid in reviewing and describing the microscopic material in the case herein reported.

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CYSTIC ANGIOMATOSIS OF THE SKELETAL SYSTEM *

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The following two cases of angiomatosis of the skeletal system seem of sufficient interest to justify a report. The term "angiomatosis" is chosen to indicate the widespread involvement of the skeletal system. The angiomatosis is designated as "cystic" because of a conspicuous correlation between the multiple angiomata and the formation of large multilocular cysts. It appears from a review of the literature that in this respect both cases are unique. We have concluded that this unusual but very striking observation may lend support to the theory that simple bone cysts may be pathogenetically related to angiomatous lesions.

CASE REPORTS

CASE 1. W. L., a white male, was first seen in 1940 at the age of three years when he sustained a fracture of the left elbow and a dislocation of the capitellum. The fracture was reduced and, when he was seen seven months later, there was an approximately normal range of elbow motion. Roentgenograms of the elbow region made at that time failed to show changes other than those directly referable to the fracture. Three years later, in 1944, he was admitted to a Charlotte hospital because of "cystic changes in the skeletal system" and received roentgen therapy to the parathyroid glands. The details of this hospitalization are not available. In October 1948 he sustained a pathological fracture of the proximal portion of the left femur while he was reaching for a ball. Russell's traction for three and a half weeks, followed by a hip spica, allowed excellent healing, with weight-bearing in four and a half months.

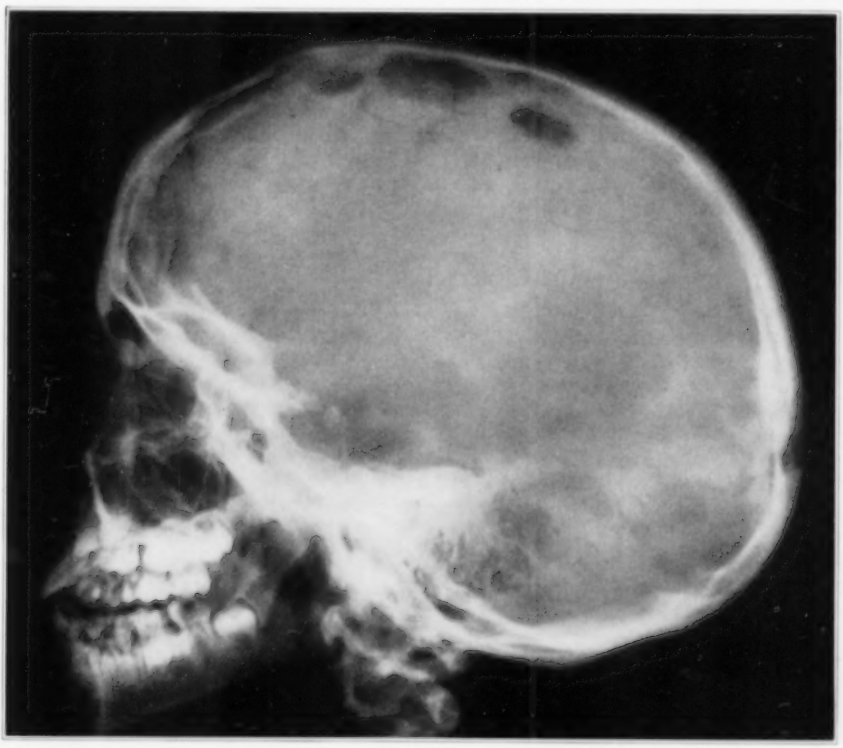

FIG. 1-A

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 31, 1952.

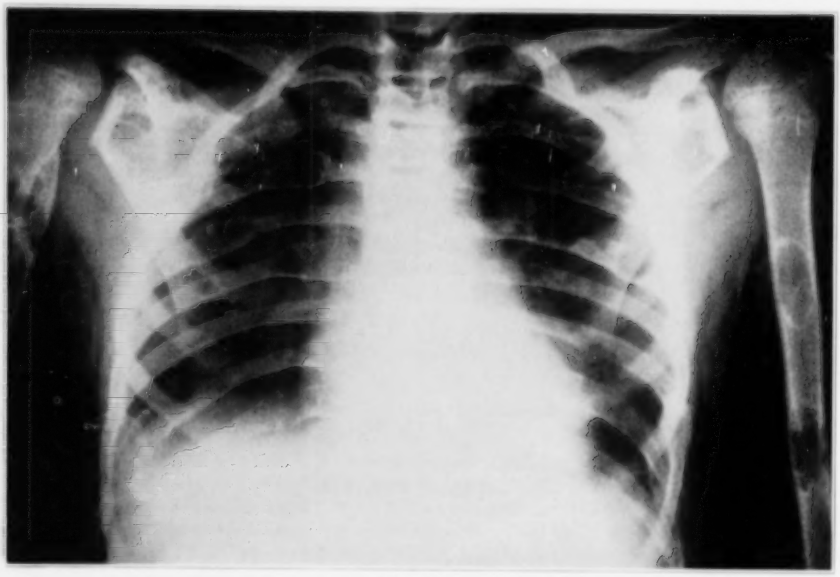

FIG. 1-B

A skeletal survey made at the time of admission showed "soap-bubble" cystic lesions in the humeri, femora, ribs, pelvis, scapulae, and skull. A biopsy of the right ilium revealed that a cystic area noted on roentgenographic examination consisted of rarefaction of the cortical bone with absence of any of the cancellous bone normally found. There was no evidence of fluid or blood, or of tumor tissue. The cystic areas were seemingly empty. Pathological examination of the tissue strongly suggested hemangioma. Because of this, after seven weeks, another biopsy was done of the right ninth rib.

Since no fluid had been noted on the previously opened cyst, the wound was flooded with normal saline solution prior to incision of the periosteum. A soft eggshell-like cortex was entered. No gas bubbles escaped from the cystic area. The rib was rather friable within the involved area of 7.5 centimeters; the remaining portion of the rib appeared normal. No discrete lining membrane was noted; a small amount of "coagulated blood" was removed from one niche. The inner surface of the cyst was smooth and glistening. No excess bleeding was encountered. The histological examination supported the previous suggestion of angioma. Because of the friability of the thin bone structures, only fragments of the shell were obtained, which precluded a definitive diagnosis. There was evidence of some callus formation.

The laboratory findings were as follows:

Red blood cells	4,560,000 per cubic millimeter
Hemoglobin	90 per cent.
White blood cells	6,150 per cubic millimeter
The differential count was normal.	
Calcium	10.5 milligrams per 100 cubic centimeters
Phosphorus	4.3 milligrams per 100 cubic centimeters
Total protein	7.8 grams per 100 cubic centimeters
Albumin	4.4 grams per 100 cubic centimeters
Globulin	3.4 grams per 100 cubic centimeters
Cholesterol	167 milligrams per 100 cubic centimeters

The urine was essentially normal; repeated Sulkowitch tests showed only traces of clouding. The concentration of alkaline phosphatase was 5.3 Bodansky units. The phenolsulfonphthalein test revealed 97 per cent. excretion in two hours. The Wassermann reaction was negative.

The patient was seen one year later, in 1949; he was walking well and had no complaints. Six months later, in June 1950, he sustained another pathological fracture in the proximal portion of the left femur. At this time a portion of the tenth rib was removed for histological study and for confirmation of the previous tentative diagnosis of angioma. He was discharged after one month with evidence of fracture healing.

Pathological report (S-4803-50). A portion of rib measuring approximately seven centimeters in length was submitted for examination. It revealed a fusiform enlargement in the center, the diameter of which was about three times that of the short portions of normal rib on either end. The specimen was removed with extreme care and a paper-thin shell of a multilocular cyst which occupied the enlarged central area was

preserved. Cross-saw sections disclosed a system of communicating cysts, most of which contained clear fluid and possessed a glistening, smooth, whitish-gray inner lining. A few of the cysts, however, contained blood, particularly those at either end of the system.

Histological sections showed that most of the bone marrow in the mid-portion of the specimen had been replaced by cystic structures which were lined by a single layer of endothelial elements. The walls of the cysts were extremely thin, often separating adjacent spaces by no more than a single or double layer of fibrocytes and thin spicules of bone. The largest spaces were in immediate juxtaposition to the bony spicules and the smaller ones were separated from them by varying amounts of hematopoietic or fatty bone marrow. Nearer the normal portions of the rib the cystic spaces became smaller and were more widely separated from each other by normal marrow. In these areas they merely appeared as irregularly distributed nests of telangiectases. All of the smaller cysts and peripheral telangiectases were engorged with blood. The large, centrally located cysts appeared empty or contained scattered red blood cells. Endothelial proliferation or capillary budding was absent in all sections. No iron-pigmented macrophages were noticed.

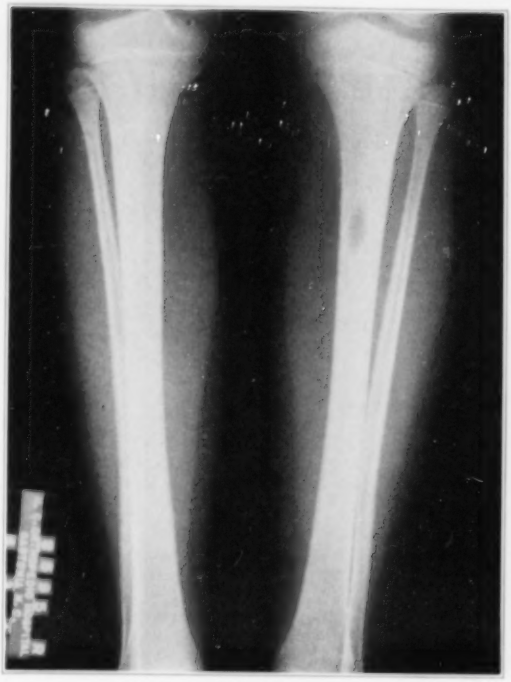

FIG. 1-C

The bone structure, although extremely rarefied in the center with only very thin residual trabeculae, failed to disclose a significant number of osteoclasts and showed only minimal osteoblastic apposition, except for the periosteal surface, where new bone was laid down in the form of perpendicularly radiating young trabeculae. The architecture of the cement lines was essentially normal (Figs. 1-A to 1-G).

CASE 2. J. J., a white female, eleven years old, was admitted to Charlotte Memorial Hospital with fever and a painful mass on the left shoulder, which had seemingly developed during the previous few hours.

When she was two years old, a tumor had been removed from the left axilla, and when she was five years old, a similar mass had been excised from the left side of the neck. Both were reported as "lymphangioma".

Physical examination did not reveal any abnormalities, except for an exquisitely tender mass on the left side of the chest extending from the medial third of the clavicle to the scapula. The mass was fluctuant; the overlying skin was normal in color and temperature. No areas of tenderness were noticed elsewhere.

Routine roentgenographic examination of the chest revealed cystlike areas of destruction in several ribs and evidence of previous fractures in two of the lower ribs.

A subsequent complete skeletal survey showed involvement of several ribs, both humeri, radii, ulnae, tibiae, femora, pelvic bones, scapulae, and skull.

The soft-tissue tumor of the shoulder was removed and a portion of the eighth rib was resected. When the cystically enlarged portion of the rib was opened, a thin-shelled multilocular cyst was encountered, which was seemingly empty. The inner lining appeared smooth and glistening. The absence of hemorrhage was conspicuous.

The child had an uneventful recovery from the operation and was discharged in good condition.

The laboratory findings were as follows:

Red blood cells	3,550,000 per cubic millimeter
Hemoglobin	71 per cent.
White blood cells	5,650 per cubic millimeter
Calcium	11 milligrams per 100 cubic centimeters
Phosphorus	4.5 milligrams per 100 cubic centimeters

The urine was normal. The Wassermann reaction was negative.

Pathological examination (S-2554-46). The tumor from the shoulder was identified as lymphangioma. The gross and microscopic examination of the rib showed essentially the same findings as those in Case 1.

FIG. 1-D

FIG. 1-E

Figs. 1-A to 1-E: Case 1. W. L., eleven years old. Roentgenograms made at admission, October 22, 1948, showing multiple cystic areas of bone and pathological fracture of left femur.

FIG. 1-F

FIG. 1-G

Figs. 1-F and 1-G: February 25, 1949. Low-power photomicrographs (× 12.5 and × 11.6), showing large, partly blood-filled spaces. Note portions of normal fatty marrow in Fig. 1-G.

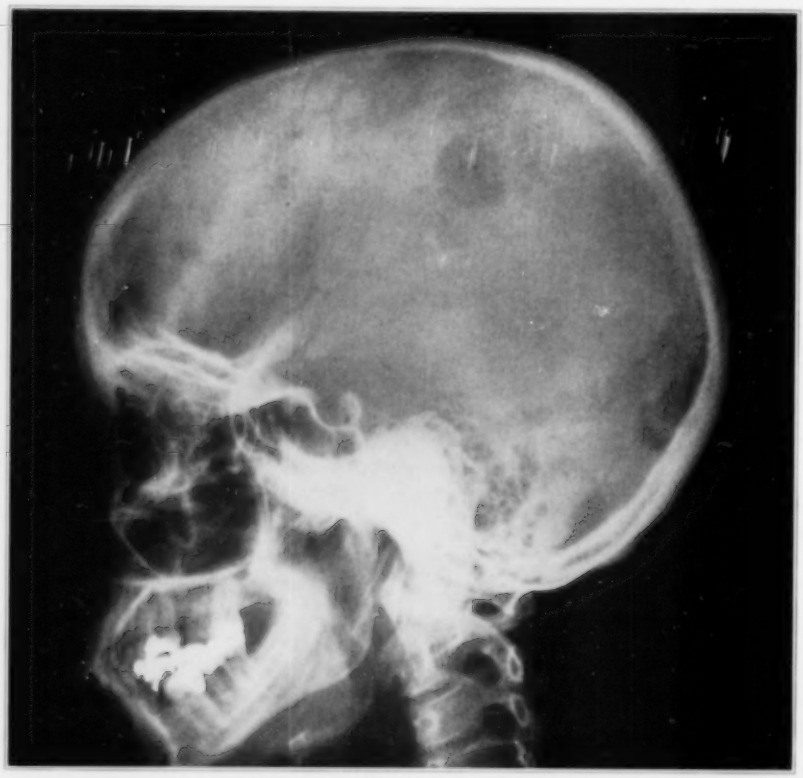

FIG. 2-A

FIG. 2-B

Only one significant difference was noticed. In contrast to the first case, many bony spicules surrounding the blood-filled sinuses were seen to be lined by osteoblasts and a thin layer of osteoid tissue; osteoclasts were rare; iron-pigmented macrophages were absent (Figs. 2-A to 2-G).

DISCUSSION

Frequency and Site of Skeletal Angiomata

The most common site of benign angioma of bone is the spine. In fact, its frequency in this location is so far out of proportion to that in other areas of the skeletal system that vertebral and extravertebral angiomata are discussed in different sections in surveys of this subject [2, 5]. This separation into vertebral and extravertebral angiomata is based upon a study by Töpfer, a pupil of Schmorl, who found that angiomata of the vertebral bodies occurred in 11.93 per cent. of a consecutive series of 2,154 autopsies. In thirty-four of his 257 cases, the lesions were found in more than one vertebral body.

Outside the spine the lesions seem to occur most frequently in the skull. Next in order of frequency are the bones of the pelvis, shoulder, and the long bones; least frequently involved are the small bones of the hands and feet.

The incidence is highest in young adults, but children may be affected. The youngest patient reported was eight years of age and the oldest was seventy-six years. The disease seems to be equally distributed between males and females and is not more prevalent in one race than another.

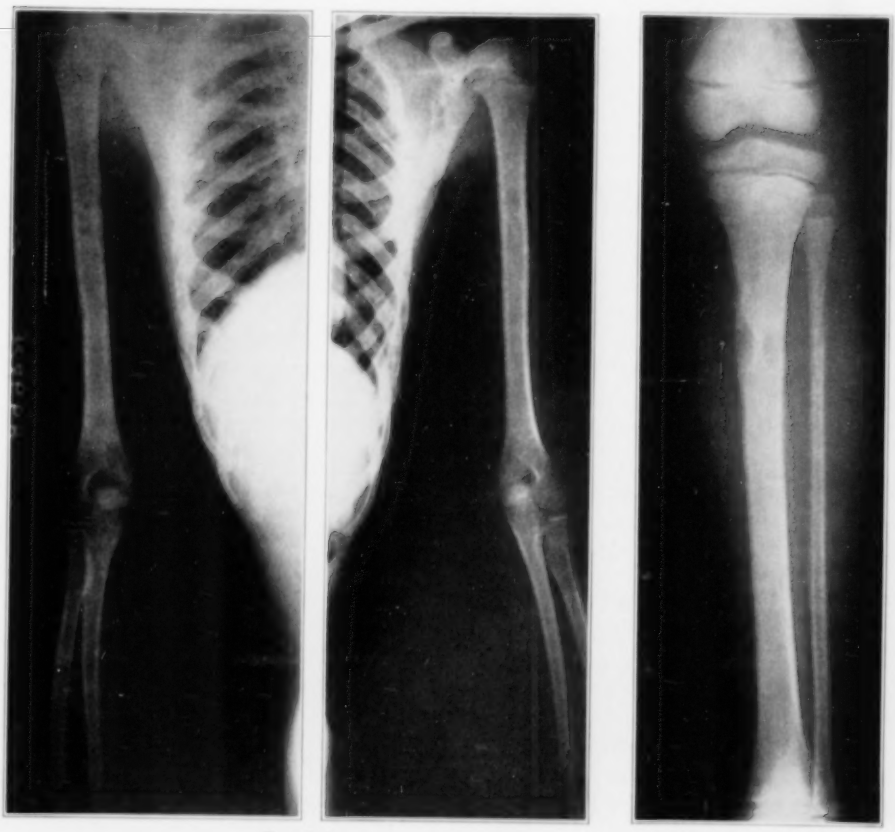

FIG. 2-C FIG. 2-D

Figs. 2-A to 2-D: Case 2, J. J., eleven years old. Roentgenograms made November 26, 1948, showing multiple cystic areas of the skeletal system.

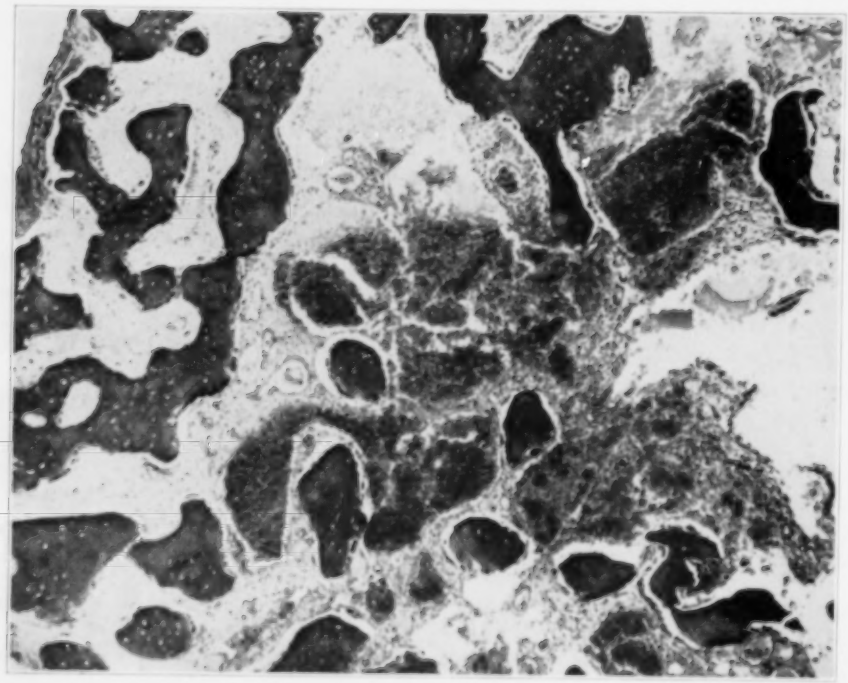

FIG. 2-E

Low-power photomicrograph (× 175), made November 26, 1948, showing most of the bone marrow replaced by thin-walled sinusoids, partly filled with blood and partly filled with plasma.

Although the total number of reported benign extravertebral angiomata is rather small, it is difficult to ascertain accurate figures, because some of the later statistics include previously reported cases without proper identification. It appears that thirty-nine cases of this type have been described, twenty of which involved the skull and nineteen, various bones of the extremities. This estimate is based upon the reports by Bucy and Capp, Geschickter and Maseritz, Ackerman and Maynard, Sherman, Handousa, Thomas, Geschickter and Copeland *, and Herzog. Including our two cases, the total number reported can be estimated as forty-one, with twenty angiomata of the skull and twenty-one in bones of the extremities.

It is difficult to state whether the astonishing difference in frequency of vertebral and extravertebral angiomata is true or merely seeming. It must be remembered that most of the angiomata of the kind described by Töpfer constituted incidental findings at autopsy and had not been detected by roentgenograms. All angiomata in other bones came to observation through clinical and roentgenographic examinations. A statistical study of the extravertebral skeletal system comparable to Töpfer's series of examinations of the spine is not available. In fact, those who have seen many angiomata of the vertebrae find it quite conceivable that tumors or malformations of the type described by Töpfer are easily overlooked in the spongiosa of bones other than the vertebral bodies. In view of the fact that angiomata frequently co-exist in the same organ, as well as in various different organs, it is rather surprising to find that multiple angiomata are, apparently, extremely rare in sites other than the vertebral bodies. We have not been able to find more than seventeen cases in which multiple benign angiomata involved the skull and extremities. Töpfer reported a combination of vertebral angiomata in nine patients with angiomata of

* Through correspondence we have learned that the angiosarcoma of the fifth metacarpal bone, in Geschickter and Copeland's Tumors of Bone, Ed. 3, p. 619, has not been reported previously.

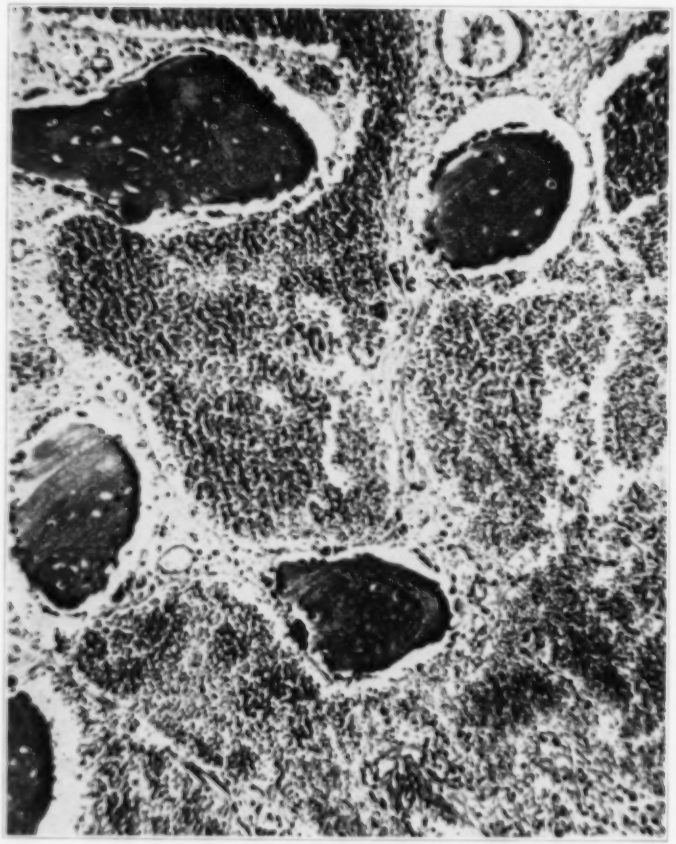

FIG. 2-F

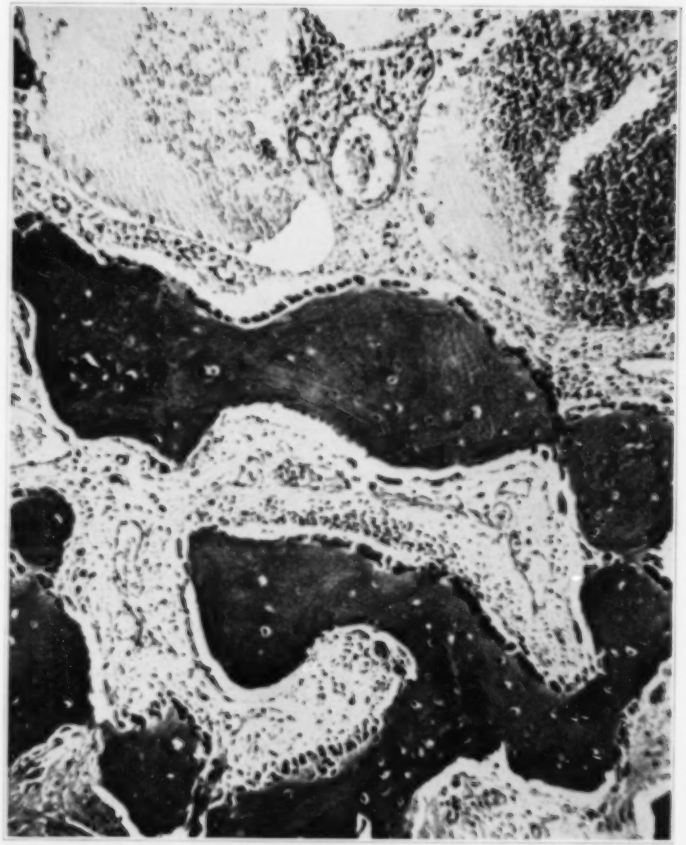

FIG. 2-G

Fig. 2-F: November 26, 1948. Medium-power photomicrograph (× 515), showing all sinuses filled with blood.
Fig. 2-G: November 26, 1948. Medium-power photomicrograph (× 475), showing osteoblastic activity in the immediate vicinity of the angioma, two large sinusoids of which are seen on one side.

the sternum, three with angiomata of the calvarium, and two with angiomata in the femur. Two other cases were reported by Curveilhier and one by Thomas. None of these can be compared with the multiplicity of lesions in both of our cases, which deserve to be classified as systemic angiomatosis of the skeletal system. As we shall point out later, there is reason to suspect that the rarity of such a condition is more seeming than true.

Pathology

A. *Tumor or Malformation.* The distinction between true hemangioma and hemangiohamartoma of the bone is difficult, because the histological examination of so-called cavernous hemangioma may not disclose evidence of growth, although the lesion may show clinical signs of progressive enlargement.

Two types of benign angioma of bone are recognized, the capillary and the cavernous types. Including Sherman's case, only five instances of capillary hemangioma have been reported. There can be no doubt that this type is truly neoplastic in nature. The cavernous type, however, does not possess the morphological earmarks of a true neoplasm. One must not subscribe to Willis's sweeping doctrine that most angiomata are not true tumors in order to admit that convincing evidence of neoplasia has not been presented in cavernous angiomata of bone. The increase in size may be due to secondary changes. It may be assumed that variation in intrasinusoidal pressure can lead to increased metallaxis of bone tissues. This, in fact, is apparent from the greatly increased activity of osteoblasts described in many cases and observed in our second case. Although osteoclasts are not as numerous in any given section as osteoblasts, new formation of bone can safely be interpreted as an incomplete reaction to grossly preponderant rarefaction. This process may eventually lead to enlargement of the surrounding bone structures and occasionally to pathological fracture. It is therefore not necessary to presuppose active angiomatous growth in order to explain the clinical appearance of enlargement. In this respect it may be of interest to note that a careful survey of the skeletal system in the second of our cases revealed enlargement of the old lesions, but no new foci of rarefaction. Until conclusive evidence of neoplasia is presented, therefore, "cavernous hemangioma" should be classified as angiohamartoma, that is, malformation rather than true neoplasia. The multiplicity of angiohamartomata in one patient, within the skeletal system as well as in the soft tissues and inner organs of the body, supports this concept. Multiple angiomata of vertebral bodies are common. Several cases of multiple angiomata of the skull are on record, and the combination with soft-tissue angiomata is well known. One of our patients had three different angiomata of subcutaneous tissue coincidental with the angiomatosis of the skeletal system. A survey of hemangiomatous syndromes can be found in Willis's book.

B. *Bone Cysts and Angiohamartomata.* One of the most startling findings in each of our cases of angiomatosis was the large multiloculated cysts which were encountered during biopsy. The first case showed multilocular cysts at the first biopsy. The angiomatous nature of the lesion was suspected at this biopsy only after correlation with the roentgenographic findings. Two subsequent biopsies were indicated for the purpose of final identification. Again, no angiomatous mass was seen grossly on either occasion. Merely cysts were visualized. Only upon histological examination could the lesion be identified as angioma. The second case showed essentially the same condition. This consistent finding in each of our cases requires explanation. Similar observations have been reported in two cases by Geschickter and Copeland. In most instances, however, the lesion is described as giving the appearance of currant jelly or as bleeding profusely.

Cysts in angiomatosis of bone are not only similar in appearance to simple bone cysts (except for their multilocularity), but they seem to have a similar explanation basically. It is well known that small angiomata in the wall of brain cysts are often difficult to find. We feel that we should encourage careful search for small angiomata in the wall of simple bone cysts.

We believe that the multilocular cysts in both our cases are not lymphangiomata but are sequelae to relatively small hemangiohamartomata. If one compares the operative and histological observations in our two cases of angiomatosis with the roentgenographic findings, one must conclude that most of the extensive changes seen in the roentgenogram are due to the formation of secondary cysts rather than angiomata proper.

In view of the fact that the great majority of hemangiomata of bone are not associated with cyst formation, we considered the advisability of setting these cases apart as a separate entity. We have found only two similar observations in the literature [5]. We felt, however, that our cases merely constitute a conspicuous variant of multiple osseous angiomata and applied to them the term "cystic angiomatosis".

Roentgenological Features

Bucy and Capp stated that the roentgenographic appearance varies with the type of bone. Flat bones, such as the skull, scapula, and pelvis have a sunburst trabeculation of unusual size, radiating usually from a common center and mostly from the flare of the bone. The periosteum may be considerably elevated, but is apparently not broken through. In the cylindrical bones the tumor is loculated. The cortex is usually destroyed, but the periosteum remains intact. Roentgenograms in other cases, however, show a peculiar soap-bubble effect extending into the periosteal zone and producing only slight bone erosion. In comparing some of the roentgenograms of angiomata of the skull, we failed to note the sunburst appearance previously stressed and from a roentgenographic standpoint the lesions appeared more like eosinophilic granulomata. Haas and Codman both emphasized the presence of small locules in lesions of small bones. Similarity between the roentgenographic findings in giant-cell tumor and hemangioma has been noted. Pohl described a fine fibrillary framework within the individual locules. In some instances the cortex overlying the expanded portion of the tumor had been destroyed. Geschickter and Maseritz concluded that roentgenographic changes in the primary hemangiomata of the extremities are similar to those in benign giant-cell tumor or osteitis fibrosa cystica, but that the lesions are more extensive and the locules are smaller and are bordered by a heavier framework of osseous tissue. In the long bones multilocular areas of destruction expand the shallow bone in one direction to paper-like thinness. The angiomata do not extend deeply into the medulla. The shaft is usually involved, but the tumor mass itself seems to stay nearer the epiphysis.

Clinical Features

The presence of a palpable tumor mass on one or more extremities may be the first indication of diffuse angiomatosis of the skeletal system. In one of our cases pathological fracture was the first indication of this condition. External evidence of angiomata, either in the skin or in the subcutaneous tissues, need not be present. The literature indicates that some cases come to the attention of the physician only because the patient has a vague ache in one or more extremities. In one of our cases the disease of the skeletal system was discovered accidentally.

After surgical exposure, the appearance of the lesion in both of our cases failed to reveal the so-called currant-jelly appearance which is characteristic of the lesion, whether or not there is profuse hemorrhage. "Coagulated blood" was noted to be present in only one niche in one of our cases. No interference with growth has been noted.

Treatment

The usual orthopaedic measures for pathological fractures seem to obtain good results in normal healing time. Angiomata affecting bone are believed to be radiosensitive. Some cures may be effected by deep roentgen therapy. Meyerding stated that hemangioma affecting bone is moderately radiosensitive under moderate dosage. With repeated x-ray

treatment at regular intervals for a number of months, the tumor gradually regresses until it has healed. Age might be a contra-indication to x-ray therapy; in both our cases no roentgen therapy was given because of its possible interference with growth.

In some cases the lesion has been cured by curettage, with or without chemical or thermal cauterization, when surgically accessible. Geschickter and Maseritz question the value of curettement and reported one case which did not respond to irradiation. They therefore advised resection of the bone as an absolute means of cure and ended with the statement that "Further observations will be necessary before any specific recommendations can be offered". In our cases radical surgery has not been indicated, inasmuch as the lesions were multiple, and some of them were inaccessible.

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DISCUSSION

Dr. Edgar M. Bick, New York, N. Y.: As I understood this paper, we have here still another possible cause for those cases of multiple bone cyst which occur at times to test our utmost skill in diagnosis. At this time I am bothered by such a case of multiple cyst which I have watched for a period of three and a half years and in which all the analytical and diagnostic procedures at our disposal have failed to disclose a systemic cause. One thing is feared when one writes down the diagnosis of simple bone cyst: We are all past the stage of just diagnosing simple bone cyst and leaving it at that. Dr. Jacobs and Dr. Kimmelstiel are quite well aware of the association of bone cysts with hemangioma in the past, but I know of no report in which a systemic cystic disease has been ascribed to hemangioma, or, as the authors prefer to call it, hemangiohamartoma. I think the substance of this paper is that we will all have to recognize one more possible differential consideration in the future study of such cases, as Dr. Jacobs and Dr. Kimmelstiel point out. I think Dr. Jacobs and Dr. Kimmelstiel are to be complimented, and I would take this opportunity to say that the committee which arranged our program is to be complimented on the selection of a paper on one of the highest levels in the history of this Academy.

Dr. Clinton Compere, Chicago, Illinois: With regard to the slides presented by the authors, I can speak more strongly than they did. In the black and white projections some of you might question the diagnosis of angiomatosis. I fortunately studied the original slides yesterday and found that the lesions were

(*Continued on page 464*)

SURGICAL TREATMENT OF EPICONDYLITIS*

BY GEORGE E. SPENCER, JR., M.D., AND CHARLES H. HERNDON, M.D., CLEVELAND, OHIO

From University Hospitals, Cleveland

The term "epicondylitis" is used to designate a symptom complex characterized by pain in the epicondylar area of the elbow which is accentuated by active contraction or passive stretching of the muscles originating from the involved epicondyle. The pathological changes are confined to the tendinous and fascial attachment of the muscles to the epicondyle and the condition is not to be confused with intra-articular lesions of the elbow joint. This disease entity has also been called "tennis elbow", "epicondylalgia", and "radiohumeral bursitis". As there were few tennis players among the patients reported here and as no instances of radiohumeral bursitis were encountered, the authors feel that the term epicondylitis is more descriptive of the process involved.

Epicondylitis involves the lateral epicondyle more than seven times as frequently as the medial. The patient complains of pain localized over the lateral aspect of the elbow joint. Commonly, the pain radiates distally over the extensor surface of the forearm and occasionally it may extend into the fingers. The pain is of a dull, aching character, but becomes sharp and severe on motions or actions which put the extensor muscles of the forearm under tension. Actions such as grasping objects (which requires setting of the extensor muscles), lifting a pitcher or a cup, wringing out clothes, employing a backhand stroke in tennis, or using a wrench or screw driver may cause sharp accentuation of the pain. One of the most common complaints is that the grip has become weak. This is apparently caused by pain experienced on setting the forearm muscles.

Examination reveals well localized, exquisite tenderness immediately distal to and over the distal edge of the lateral epicondyle. The sharp pain of which the patient complains may be reproduced by dorsiflexion of the fingers and wrist against resistance or by passive stretching of the extensor muscles of the forearm. This is best demonstrated by completely extending the elbow and forcibly flexing the hand and wrist. A useful test is to have the patient attempt to lift a small chair and instruct him to grasp it with the forearm pronated. The patient will experience immediate sharp pain referred to the region of the lateral epicondyle. Flexion of the fingers or wrist against resistance is painless, unless setting of the extensors is required. Local findings other than the tenderness described are minimal. Local swelling and redness are only rarely encountered. Roentgenograms of the elbow may reveal a small deposit of calcium immediately distal to the lateral epicondyle, and there may be a moderate roughening of the epicondyle suggestive of a mild periostitis. No other bone abnormalities are noted.

Epicondylitis involving the medial epicondyle produces a similar clinical picture on the opposite side of the forearm. The patient complains of pain over the medial aspect of the elbow, which may radiate distally over the volar surface of the forearm. Activities or motions which subject the flexor group of muscles to tension accentuate the pain. Activities which require a strong grasp, pronation against resistance, or forcible flexion of the wrist are particularly painful. Physical examination reveals well localized tenderness immediately distal to the medial epicondyle and sharp pain is reproduced by flexing the hand or wrist against resistance. Passive hyperextension of the wrist and fingers also reproduces the pain.

The pathological process involved in the symptom complex described has been a disputed subject and the literature reveals a variety of opinions. Preiser believed that the symptoms were due to arthritis of the radiohumeral joint. Bähr thought a radiohumeral

* Presented at the Robert Jones Club, Cleveland, Ohio, October 27, 1951.

bursitis was responsible for producing the pain. Osgood, Carp, and Dittrich agreed with this theory and reported cures following surgical excision of the radiohumeral bursa. A synovitis of the radiohumeral joint secondary to trauma sustained through extension and supination of the elbow was suggested by Trethowan as the underlying factor. Bergmann reported a periosteal thickening of the epicondyle with a periostitis or an osteitis. The theory of periosteal tear or fracture with an accompanying periostitis or myofascitis, as described by Hanson and Horwich and by Cyriax, provides a logical explanation for the symptom complex and is probably the most acceptable.

In the cases presented in this study in which surgical exploration was done, the deep fascia just distal to the epicondyle and the tendinous origin of the muscles from the epicondyle frequently appeared somewhat thicker and denser than usual, but grossly no real abnormality was noted, except in two cases in which small calcium deposits were present in the tendinous attachment. In those cases in which some of the excised fascia was examined histologically, all that could be demonstrated was chronic inflammation.

The patients with epicondylitis who have been treated at University Hospitals have come from all classes of society and have had varied occupations. Very few of them were tennis players, but the condition does appear to be more common in people whose occupations involve repetitive flexion and supination. It was also noted that frequently an episode of epicondylitis followed direct trauma over the epicondyle.

In most cases, the symptoms associated with epicondylitis will disappear after conservative treatment. This may consist of restricted activity and physical therapy, local procaine infiltration with or without manipulation, or temporary splints [4, 8, 10, 11, 14]. Roentgen therapy may be a valuable conservative therapeutic agent. The usual course of roentgen-ray treatment as given in University Hospitals of Cleveland consists of three treatments of 200 r in air to each of three fields—anterior, posterior, and lateral, one field being treated every other day. (Modality 220 kilovolts, 0.5 millimeter copper, 1.0 millimeter aluminum filter with a half-value layer of 1.2 millimeters copper.) There are a considerable number of patients, however, whose symptoms persist to a disabling degree in spite of conservative measures. These are the patients with whom we are concerned in this report.

Between June of 1941 and June of 1951, symptoms persisted in spite of conservative measures in forty-nine cases of epicondylitis in forty-four patients treated at University Hospitals. These patients were operated upon for relief of symptoms. It should be emphasized that the patients operated upon were those with persistent pain who remained handicapped in spite of conservative therapy. The previous therapy had consisted of heat of all types including diathermy, as well as "cock-up" splints, local injections of procaine, roentgen therapy, rest, and exercise. Although some of these patients had been helped temporarily by these procedures, symptoms had gradually recurred and were, in most cases, as intense as those experienced prior to treatment or more so.

FIG. 1-A

A one and one-half inch curved linear incision is made.

In this series, there was an equal distribution of males and females. The average age of the patients was forty-three years. The oldest was sixty-six and the youngest twenty-two. The average duration of symptoms

from onset until surgical intervention was 6.1 months.

The right arm was involved in twenty-nine cases (59 per cent.) and the left in twenty (41 per cent.). Four patients had bilateral involvement. In three of these both arms became involved simultaneously, while the other patient had involvement of the opposite extremity two years after the original episode. In forty-three cases the lateral epicondyle was involved and in six, the medial epicondyle.

Two slightly different surgical approaches were made to the problem. Both were designed to accomplish the same result, namely, a release of the fibrous attachments to the epicondyle. Forty-nine operative procedures were performed (four bilateral and one recurrent). Twenty-three of the forty-nine operative procedures consisted in a fasciotomy (Figs. 1-A to 1-C). Through a linear incision, one and one-half inches long, a simple transverse division of the deep fascial covering of the common extensor group of muscles, one centimeter distal to the lateral epicondyle, was performed. The intermuscular septum was also divided. Only the skin and subcutaneous tissue were closed. In those instances in which the medial epicondyle was involved, a similar procedure was carried out one centimeter distal to the medial epicondyle. In the remaining twenty-six cases, the fascial and tendinous attachments to the epicondyle were released by the stripping of these attachments from the epicondyle with a sharp elevator. The muscles were permitted to retract and only the skin and subcutaneous tissue were closed. A choice between a simple fasciotomy and a subperiosteal stripping was determined by the individual surgeon's preference. The procedure may be carried out equally well under general or local anaesthesia.

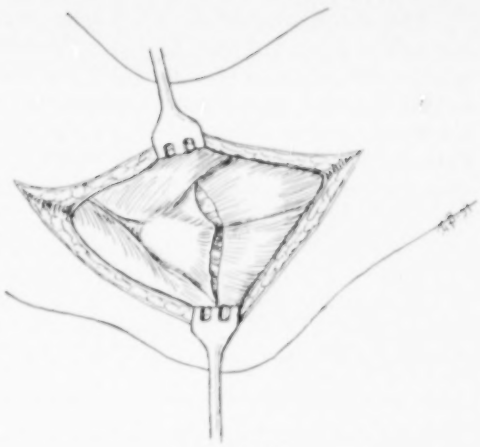

FIG. 1-B

A simple transverse division of the deep fascial covering of the common extensor group of muscles is performed 1.0 centimeter distal to the epicondyle. The intermuscular septum is also divided.

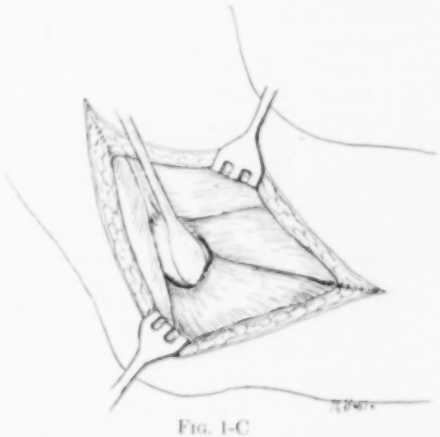

FIG. 1-C

An alternative procedure is to release the fascial and tendinous attachments to the epicondyle by stripping these attachments from the epicondyle with a sharp elevator.

In both procedures only the subcutaneous tissue and skin are closed.

After the operation, the arm was placed in a sling for the patient's comfort, but the patient was encouraged to use the hand and arm as soon as he could do so comfortably. These patients remained in the Hospital an average of only two days after operation. Convalescence was, as a rule, quite rapid. The average number of days before the patient returned to his regular occupation was 13.5. The shortest period was three days and the longest seventy-two days. The average number of days before the patients were completely asymptomatic was 27.1, the longest being seventy-two days and the shortest seven days.

These patients have been followed for an average of 13.5 months. The only complication has been a delayed hematoma of the wound. This occurred in two cases.

The classification of the end results has been divided into three groups, consisting of excellent, good, and poor. Under excellent are included those patients who were asymptomatic and normal at the time of the end-result evaluation. Those patients are classified as having a good result who were relieved of their symptoms and satisfied with the result, but who do have an occasional twinge of pain or slight tenderness on physical examination. Patients classified as having a poor result were those who had had recurrence or whose symptoms were not adequately relieved. The end results of the forty-nine procedures were excellent in 67.3 per cent.; good in 28.6 per cent.; and poor in 4.1 per cent. There was one recurrence following a subperiosteal stripping, which was relieved later by fasciotomy.

When the results were divided according to the type of surgical procedure performed, it was found that the results following fasciotomy were excellent in 78.7 per cent., good in 17.3 per cent., and poor in 4.0 per cent. The results following subperiosteal stripping were excellent in 57.6 per cent., good in 38.4 per cent., and poor in 4.0 per cent.

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THE SURGICAL MANAGEMENT OF FRIEDREICH'S ATAXIA

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The hereditary ataxias are a group of closely related clinical syndromes characterized by degeneration of some part of the spinocerebellar nervous system, on a hereditary or familial basis. The manifold sites of degeneration produce a diversity of symptoms and account for the numerous eponymous syndromes. Of these, the most common is that originally described by Friedreich in 1863. This study attempts to evaluate the role of surgery in the management of Friedreich's ataxia. It includes forty-five patients suffering from musculoskeletal disabilities arising from this disease who received surgical treatment at the New York Orthopaedic Hospital during the twenty-year period from 1931 to 1951.

The onset of Friedreich's ataxia usually occurs in childhood or adolescence. The main symptom is ataxia of the lower limbs, commonly associated with foot deformity. Usually there is a loss of kinaesthetic sensibility in the lower limbs. Ankle jerks disappear and later the knee reflexes also disappear. There is a positive Babinski plantar response, and nystagmus is common. Progress of the disease is slow and steady; ataxia of the upper limbs, intention tremor, and scanning speech may develop, and a marked general hypotonia is noted. By the age of thirty, the patient is often incapacitated. As a result of paralysis, muscle weakness, and deformity, he becomes bedridden. Death from intercurrent disease frequently occurs in the fourth decade of life.

Sporadic instances have been found and atypical forms are fairly common. A case otherwise typical may, for example, show only unilateral foot defect. Abortive forms occur in which there is no progressive involvement. The Roussy-Lévy syndrome, consisting of familial claw-foot with absence of deep tendon reflexes, may be considered either as an abortive form of Friedreich's ataxia or as a *forme fruste* of Charcot-Marie-Tooth peroneal muscular atrophy. Roth has reported cases in which a direct and familial connection between Friedreich's ataxia and peroneal muscular atrophy was established. The many transitional forms which lie between the borderlands of the two diseases render exact classification difficult. Doubtful or marginal cases have not been included in this study.

The essential pathological change is a degeneration, of unknown origin, occurring in the posterior and caudal regions of the spinal cord. The portions involved are the columns of Goll and of Clarke, and the pyramidal and dorsal spinocerebellar tracts. In addition, there may be degeneration of the anterior horn cells. The degenerated areas are gradually replaced by secondary glial tissue.

In the twenty-year period previously mentioned, a total of 152 cases of Friedreich's ataxia were diagnosed. Operation was advised in fifty-two. All these patients were ambulatory and their deformity was correctable. Of this number, five refused operation, and two must be excluded because of diagnostic error, discovered later. Forty-five patients therefore remain for study. These comprise twenty-one males and twenty-four females.

PRESENTING SYMPTOMS

The onset of symptoms or the recognition of the defect took place at ages varying from early infancy to fifteen years. The average age incidence was 10.2 years. Usually there was a time lag of two or three years between the onset of symptoms and first presentation at the Hospital.

The clinical picture showed one or more complaints, of which the most frequent were falling easily, stumbling, clumsiness, and awkwardness of gait. This usually was noticed

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first by parents or teachers. The patient was prone to frequent twisting of the ankles, early foot fatigue, and difficulty in obtaining comfortable shoes. Parents observed that their children's shoes wore out rapidly and easily became misshapen. Progressive foot deformity was a common symptom and was of an insidious nature. The average age at the time of presentation at the Hospital was approximately thirteen years; patients who complained principally of painful feet, however, fell into an older group whose average age at presentation was twenty years. The main presenting symptoms and their frequency are indicated in Table I.

TABLE I

Main Symptoms	No. of Patients	Per cent.	Average Age of Presentation (*Years*)
Awkward gait, stumbling, falling	32	71.1	13.2
Progressive foot deformity	27	60.0	13.8
Painful feet	11	24.4	20.3
Foot fatigue	8	17.7	12.8
Difficulty with shoes	6	13.3	13.4
Spine deformity	3	6.6	13.8

All but two of the patients exhibited foot defects requiring surgery. Although in many the hands showed minor wasting of the thenar eminence and of the interossei, the condition was neither deforming nor disabling; severe hand disability occurred in only one instance. Scoliosis rarely was a presenting symptom and usually was detected only by complete clinical examination. Generally it was mild and non-progressive; surgical correction was necessary in only two cases.

The most common deformity was symmetrical claw-foot with marked elevation of the longitudinal arch, prominent metatarsal heads, widening of the fore part of the foot, and hyperextension of the lesser toes. Frequently deformity of the great toe was present as well, consisting of dorsal flexion at the metatarsophalangeal joint and plantar flexion at the interphalangeal joint. In its early phases, the malposition can be corrected by passive elevation of the metatarsal heads; later, however, restriction of normal foot flexibility occurs and the deformity becomes fixed. Equinus was usual, while in just under half the cases varus deformity was present and increased the disability. The incidence of the main components of foot deformity is shown in Table II.

TABLE II

TYPES OF FOOT DEFORMITY

Foot Deformity	No. of Patients	Per cent.
Cavus	38	84.4
Claw Toes	33	73.3
Equinus	25	55.5
Varus	21	46.6
Drop-foot and flail foot	2	4.4

There was definable muscle weakness in twenty-seven cases. Ten patients were rated normal, and six had no record of original muscle status. Table III shows the distribution of muscle weakness. Muscle imbalance clearly is a significant factor in the genesis of claw-foot. The overactive long extensor tendons, which are invariably taut and like a bowstring, hold the toes in their clawed position. This overactivity may be in compensation for a weakened tibialis anterior. The most common definable muscle weakness was peroneal, either isolated or combined with paresis of the tibialis anterior. This preponderance of

TABLE III

DISTRIBUTION OF MUSCLE INVOLVEMENT IN FORTY-THREE PATIENTS WITH FOOT DEFORMITY

	No. of Patients
Muscle Weakness	
Peroneal	6
Anterior tibial	1
Peroneal and anterior tibial	10
All foot dorsiflexors	8
Total absence of all foot dorsiflexors	1
Flaccid paralysis of all foot musculature	1
Normal musculature	10
Unrecorded	6
Total	43

peroneal weakness in claw-foot was previously noted by Golding-Bird, who advanced the theory that the resultant overactivity of the tibialis posterior approximates the metatarsal heads to the heel and removes the strain of the tread from the plantar fascia, allowing it to contract and produce a pes cavus.

Extrinsic muscle imbalance, however, cannot be the complete explanation of claw-foot, for in many other conditions, similar muscle weakness does not lead to the characteristic deformity. According to Duchenne, claw-foot is caused by weakness of the intrinsic musculature of the foot. The action of the intrinsic muscles, in opposition to the long extensors, is to flex the metatarsophalangeal joints. When the intrinsic muscles are inactive, the long extensor tendons are unopposed. The most probable explanation of the genesis of claw-foot, therefore, is a combination of intrinsic and extrinsic muscle imbalance. Isolated weakness of the intrinsic muscles rarely can be demonstrated in typical claw-foot.

TABLE IV

TYPES OF PROCEDURES

	No. of Patients	No. of Feet
Stabilizations		
Triple arthrodesis	34	63
Naughton Dunn arthrodesis	2	2
Pantalar arthrodesis	3	5
Tendon transfers and tendoplasties:		
Extensor digitorum longus to middle cuneiform	16	29
Extensor hallucis longus to first metatarsal	18	34
Extensor digitorum longus and extensor hallucis longus to middle cuneiform	2	4
Anterior tibial to middle cuneiform	1	1
Tenotomy of posterior tibial	3	6
Calcaneal tendon lengthening	5	8
Other Procedures		
Plantar fasciotomy	25	46
Osteotomy of first metatarsal	12	21
Arthrodesis of proximal interphalangeal joints	8	12
Amputation of fifth toe	4	7
Arthrodesis of interphalangeal joint of hallux	21	39
Dorsal wedge resection of foot	2	2
Arthrodesis of metatarsocuneiform joint	1	1
Revision of talonavicular pseudarthrosis	3	3
Revision of talotibial pseudarthrosis	1	1
Revision of subtalar arthrodesis	2	2
Spine fusion	3	
Opponens tendon transferred to thumb	1	2 hands

OPERATIVE PROCEDURES

Ages at operation ranged from nine to thirty-three years and averaged 14.9 years. In twenty-eight cases, multiple operative procedures involving two or more admissions to the Hospital for surgery were necessary. Three patients required spine fusion; two for progressive scoliosis and one for advancing round-back deformity. In one case, both spine fusion and correction of foot deformity were undertaken. Operative procedures for the correction of foot deformity were performed in forty-three cases. In bilateral cases, it was usual for both feet to be operated upon at the same time by two surgical teams.

Four patients had unilateral foot involvement only, so that in all eighty-two feet were implicated. Each foot presented a separate problem requiring a special decision. The purposes of the operation were to correct deformity, eliminate instability, and relieve pain, thus enabling the patient to stand with his feet in normal position and alignment and to walk with improved gait. Bone surgery was performed early even in the milder cases. In this way, progressive deformity was arrested, less bone was sacrificed, and correction was easier technically. In children, bone surgery was routinely avoided until bone maturity was adequate.

The basic procedure was a subtalar arthrodesis, involving resection of the talocalcaneal, talonavicular, and calcaneocuboid joints, with correction of deformity by adequate wedging of the resections. This triple arthrodesis was undertaken in thirty-four patients (sixty-three feet). The Naughton Dunn type of arthrodesis, requiring resection of the talocalcaneal and calcaneocuboid joints, with excision of the navicular and fusion between the talus and the cuneiforms, was necessary in only two cases (two feet) in which the cavus deformity was so severe that removal of the navicular bone was required.

The equinus deformity usually was correctable by adequate cuneiform resection during the subtalar stabilization. Hibbs first noted that in typical claw-foot, the main deformity occurred around the mid-tarsal joint and the apparent equinus could be eliminated by correction of the cavus. Lengthening of the Achilles tendon was necessary in only five cases. In order to relax the soft tissues on the plantar aspect of the foot, subcutaneous plantar fasciotomies were performed concurrently with stabilization in twenty-five cases. Pantalar arthrodesis was used in three patients,—in two bilaterally for the correction of drop-foot resulting from the disease, and in the third for drop-foot due to postoperative peroneal tourniquet palsy.

In dealing with the muscle imbalance, subtalar arthrodesis usually was the first and basic procedure. Tendon transplantation followed stabilization and the correction of bone deformity, but only after a six-week interval and not concurrent with the arthrodesis. Of twenty-eight patients in whom tendon transplantations were performed, twenty-five underwent associated bone surgery.

Overactivity of the extensor hallucis longus produces a prominence of the ball of the foot and accentuation of the equinus of the fore part of the foot. When this deformity had become fixed, it was corrected by an osteotomy at the base of the first metatarsal, performed concurrently with the subtalar stabilization. This procedure was adopted in twelve cases. When the drop of the fore part of the foot could be reduced passively, it was corrected by a tendon transplant.

The tendon transfer most frequently performed was that of the extensor hallucis longus to the neck or shaft of the first metatarsal (eighteen cases). By this means the deforming factor was removed from the hallux, foot dorsiflexion was aided, and the first metatarsal was elevated. In association with this transfer, the interphalangeal joint of the hallux invariably was fused to prevent buckling of the hallux by the unopposed flexor (twenty-one cases). In one additional case, this was performed without tendon transfer because the extensor hallucis was paralyzed.

Another common tendon transplantation performed was that of the extensor digitorum longus to the middle cuneiform (sixteen cases). This transfer removes the deforming

action of the long extensors on the toes and converts them into active dorsiflexors of the foot.

The remaining five tendon transfers performed are listed in Table IV. In each case there was a specific indication for following a different pattern of transplantation. The series included one case of bilateral transfer of the flexor sublimis tendon of the fourth finger to the thumb in order to regain thumb opposition. Table IV indicates the type and incidence of the operative procedures.

As the purpose of this study is to assess the value of surgical interference in the treatment of Friedreich's ataxia, detailed reports are here presented of the eight patients in the series who have had a minimal follow-up of ten years since their first operation.

CASE REPORTS

Case 1. S. L. C., when first seen in 1937, was a twelve-year-old boy with a three-year history of progressive foot deformity, unsteady gait, and frequent falls. This was interfering with his schooling and general locomotor ability.

Examination showed severe bilateral pes equino-cavo-varus and clawed great toes. The peronei were rated weak.

Neurological examination revealed bilateral Babinski responses. The knee jerks were present, but the ankle jerks were absent. There was nystagmus, but no sensory disturbance.

In 1939, bilateral triple arthrodeses were performed, followed six weeks later by bilateral transplantation of the external hallucis longus to the neck of the first metatarsal and arthrodesis of the interphalangeal joint of the hallux. Following operation, the patient's locomotor ability was much improved; he had a fair gait and could walk more than a mile. Seven years after operation, further progression of the Friedreich's ataxia became obvious and incoordination of gait increased. When he was last seen, twelve years after operation, the feet were in good position and the patient was still able to walk, but with a marked waddling gait; this was due to bilateral abductor lurch as a result of weakness of the hip abductors. All hip muscles were rated weak and there was moderate ataxia.

In this case operation effected a delaying action, prolonging the ability to walk in a person who, because of combined ataxia and severe foot deformity, would unquestionably have been rendered bedridden otherwise. A marked improvement in gait resulted from operation.

Case 2. T. D., a nine-year-old girl, was first seen in 1938. She had a six-year history of deformity of the left foot which had recently become more severe. She complained of turning her left ankle frequently and of instability in walking.

Examination revealed a cavus deformity of the left foot and a heel varus of 10 degrees. There was marked overactivity of the extensor hallucis longus, producing a prominence of the first metatarsal head in the sole of the foot, and the peroneals were weak. The right foot was normal. Neurological examination showed that the right knee jerk was present but feeble and the left knee jerk was absent. Ankle jerks were absent and there was a Babinski plantar response on the left. There was a loss of vibration sense in the feet. No nystagmus was present.

In 1939 a left subtalar arthrodesis was performed. The extensor hallucis longus was transplanted to the shaft of the first metatarsal. Following operation there was a failure of fusion between the talus and the navicular and recurrent supination of the metatarsus occurred. In 1941, the subtalar arthrodesis was revised and an arthrodesis of the interphalangeal joint of the hallux was performed. Sound bone fusion in good position was obtained. When last seen in 1951, the patient was fully active. She had been graduated from college and had married. The left foot was in good position, while the right foot then showed a very high arch with marked drop of the fore part of the foot. A mild scoliosis had developed.

In this case the main deformity was unilateral and the other foot became involved only after a prolonged period. The correction of the original foot deformity enabled the patient to enjoy normal activity. Here, progression of the disease has been unusually slow.

Case 3. J. K., a woman, thirty-three years old, was first seen in 1937. She complained of pain in the right foot. Examination revealed a right claw-foot with a painful clavus over the fifth toe, prominent metatarsal heads, and a marked drop of the first metatarsal. The left foot appeared to be normal.

Neurological examination showed knee jerks to be present with reinforcement and ankle jerks to be absent. There was a bilateral Babinski plantar response. Nystagmus was present.

In 1938, an amputation of the right fifth toe was undertaken. Pain persisted in the right foot under the metatarsal heads, caused principally by the overactive long toe extensors and the persistent equinus of the fore part of the foot. In 1941, transplantation of the extensor digitorum longus to the middle cuneiform and arthrodesis of the proximal interphalangeal joints of the second, third, and fourth toes of the right foot were performed. In 1950, the patient returned, complaining of painful clavi of the right foot, particularly over the fourth toe. It was then noticed that she had marked peroneal weakness and that the tendon transplant was working well. Resection of the middle phalanx of the right fourth toe was then performed. When last seen in 1951, the patient was pursuing normal activities.

FIG. 1-A

Fig. 1-A: Case 5. J. C. A persistent high arch with prominence of the first metatarsal head.

Fig. 1-B: Lateral roentgenogram of the right foot. The marked cavus was accentuated by the steep incline of the metatarsals. Note the elevated, retracted claw toes.

Fig. 1-C: Lateral roentgenogram of the right foot, twelve years after operation, showing sound fusion following triple arthrodesis. The cavus deformity has been corrected and the metatarsals have preserved a normal inclination.

FIG. 1-B

FIG. 1-C

FIG. 1-D

FIG. 1-E

Fig. 1-D: Anteroposterior roentgenogram made on the same day as Fig. 1-C. Arthrodesis of the interphalangeal joint of the hallux and of the proximal interphalangeal joint of the toes had been performed. The fifth toe had been amputated and the claw-toe deformity has been corrected.

Fig. 1-E: Photograph made twelve years after operation. The feet have a normal appearance and the deformity has been corrected.

This patient belonged to a rather later age group than normal. It is of interest to note the unilateral nature of the claw-foot and the absence of instability.

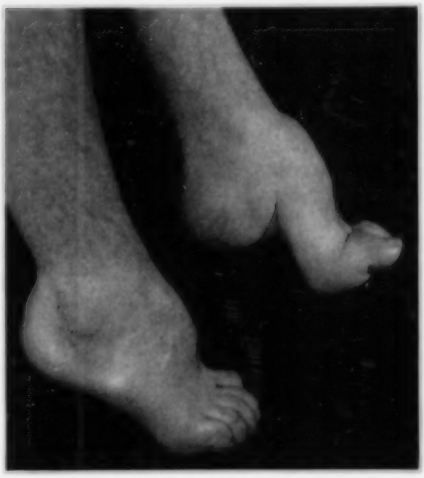

FIG. 2-A

Case 8. S. R. A characteristic severe bilateral claw-foot. Note the deep flexion crease in the sole resulting from the marked equinus of the metatarsus.

CASE 4. J. G., an eighteen-year-old girl, was first seen in 1938. She had a seven-year history of pain and deformity of the right foot. The right foot showed a moderate claw-foot deformity with a high arch and retraction of the toes. There was a drop of 60 degrees in the fore part of the foot and no heel varus. The left foot was normal.

Neurological examination showed the knee jerks to be equal and active; ankle jerks were absent and there were equivocal plantar responses. There was a loss of vibration sense and proprioceptive sensibility in the right foot.

In 1939, arthrodesis of the right first metatarsocuneiform joint and plantar fasciotomy were performed. Two months later, transplantations of the extensor digitorum longus to the middle cuneiform and of the extensor hallucis longus to the first metatarsal were performed. In addition, arthrodesis of the interphalangeal joint of the hallux was carried out. Following operation there was pain under the metatarsal heads which persisted despite all forms of conservative therapy. In 1940, a wedge osteotomy of the second and third metatarsals was undertaken. The effect of this operation was to transfer the pain laterally under the heads of the fourth and fifth metatarsals. In the dependent position the right foot was cold, clammy, and cyanotic. No dorsalis pedis or posterior tibial arteries were palpable and the diminution of circulation was thought to be due to a vascular spasm.

FIG. 2-B

FIG. 2-C

The patient was seen again in 1946; at that time she was using canes. She had been unable to put her full weight on the right foot since the previous operation because of persistent pain, particularly under the first metatarsal head. Further surgery was refused by the patient. When she was last seen in 1950, her right foot was still painful, stiff, and fibrosed, and she had a marked limp.

This case must be considered as a functional failure.

CASE 5. J. C., an eighteen-year-old male, was first seen in 1939. He had a five-month history of painful feet. He had had deformed feet since childhood, but they had not troubled him previously.

Examination showed bilateral claw-foot with high arches, claw toes with taut extensor tendons, and callosities under the metatarsal heads (Fig. 1-A). The marked drop of the fore part of the foot caused an apparent equinus. His gait was normal.

Neurological examination showed the knee jerks to be present with reinforcement, while ankle jerks were absent. There were bilateral Babinski responses. Nystagmus was present. There was no ataxia.

In 1939, bilateral triple arthrodesis and plantar fasciotomy were undertaken, followed two months later by bilateral transplantation of the extensor hallucis longus and the extensor digitorum longus to the middle cuneiform, as well as bilateral arthrodesis of the interphalangeal joint of the hallux. The operations were successful; the fusions became solid in good position and the tendon transplants worked well.

In 1942, the patient returned because of symptomatic hammer toes of the right foot and in 1946, because of symptomatic hammer toes of the left foot. Fusions of the proximal interphalangeal joints of the second, third, and fourth toes were undertaken on both feet, as well as an amputation of the right fifth toe.

Fig. 2-B: Lateral roentgenogram of the right foot. There is a normal relationship between the tibia, the calcaneus, and the talus. The cavus deformity is centered at the mid-tarsal area. Note the steep incline of the metatarsal heads and the elevated claw toes.

Fig. 2-C: Lateral roentgenogram of the right foot ten years after operation. Sound bony union following the triple arthrodesis was evident and there was adequate correction of the previous deformity. The interphalangeal joint of the hallux was fused. Mild hammer-toe persisted.

Fig. 2-D: Photograph made ten years after correction of the deformity.

FIG. 2-D

The patient was last seen twelve years following his original operation, during which interval there had been no progression of the disease. The feet were in good position and he reported that he could walk and run as well as anyone else. He had served for three years in the Air Force (1942–1945) and is now working full time as a draughtsman.

This case represents the abortive, non-progressive type of Friedreich's ataxia. The foot disability, which was the main manifestation of the disease, was corrected by surgical intervention, after which the patient was able to lead a normal life.

CASE 6. R. E., a fourteen-year-old schoolboy, was first seen in 1940. He had a three-year history of progressive foot deformity and complained of increasing clumsiness on his feet and of falling frequently. In his own words, he "tripped over his feet". There was a family history of high-arched feet.

Examination showed bilateral claw-foot with moderate cavus and a varus deformity of the left foot. The power of the peroneal and anterior tibial muscles was noticeably weak.

Neurological examination showed the knee jerks to be active and equal and the ankle jerks equal but diminished. There were bilateral Babinski plantar responses and nystagmus. Ataxia was present, but there were no sensory changes.

In 1941, bilateral triple arthrodesis and plantar fasciotomy were performed. Three months later, the common toe extensors were transplanted bilaterally to the middle cuneiform. Despite a local wound infection, the fusions became solid in good position. In 1942, the patient was rejected by the Army because of his foot condition. When the patient was last seen in 1951, bilateral hammer-toe deformity of the outer four toes had developed. The tendon transplants were working well and he had no disability other than a mild ataxia. He was working full time as a motor mechanic and expressed satisfaction with his general condition.

In this case disability was confined to the lower limbs. Upon correction of the deformity, the patient was enabled to lead a normally active life. If the patient desired, the present toe deformities could be corrected by interphalangeal arthrodeses.

CASE 7. F. M., an eleven-year-old girl, was first seen in 1940. She had a three-year history of progressive foot deformity.

Examination showed a highly arched right foot with 10 degrees of heel varus; there was a "cock-up" deformity of the toes and a prominence under the first metatarsal head. The left foot showed only moderate cavus and mild claw toes.

Neurological examination showed that the knee and ankle jerks were bilaterally present but feeble. There was a definite Babinski plantar response on the right and an equivocal one on the left. No nystagmus was present. There was diminution of vibration sense in the legs.

In 1941, operations were performed on both feet. On the right, a triple arthrodesis was carried out, followed three months later by transplantation of the long toe extensor tendons to the middle cuneiform and of the extensor hallucis longus to the first metatarsal. At the same time, the interphalangeal joint of the hallux was arthrodesed. On the left foot, similar tendon transplantations were undertaken, but no subtalar stabilization was performed.

By 1945, due to the overactivity of the anterior tibial muscle, moderate inversion had developed in the right foot, while the left foot showed progressive equinovarus deformity. Operations were again carried out

on both feet. On the right, in order to remove the deforming factor, the anterior tibial tendon was transplanted to the middle cuneiform, and on the left, a Naughton Dunn type of arthrodesis was performed.

In 1951, bilateral amputation of the fifth toe was performed because of pain due to flexion deformities.

When last seen, the patient was leading a semi-active domestic life, but was restricted in her general activities because of the progression of muscle weakness.

Subtalar stabilization should probably have preceded tendon transfers on the left foot. The condition was moderately progressive; however, the patient's feet are now stable and she is able to get around without the added interference of foot deformity.

Case 8. S. R., a nineteen-year-old male, was first seen in 1941. He had an eight-year history of progressive foot deformity, and for the past year his feet had been painful. Examination revealed severe bilateral claw-foot with very marked drop of the fore part of the foot. The toes were retracted and the metatarsal heads were prominent. Dorsiflexion was limited bilaterally to 120 degrees. There was weakness of the peroneal and anterior tibial muscles, and the patient walked with a high-stepping gait.

Neurological examination revealed absence of knee and ankle jerks bilaterally, feeble bilateral Babinski plantar responses, and absence of vibration sense over the feet. There was slight nystagmus and atrophy of the right thenar eminence.

In 1941, bilateral triple arthrodesis and plantar fasciotomy were performed. Three months later, bilateral tendon transplantations were undertaken of the extensor hallucis longus to the neck of the first metatarsal and of the extensor digitorum longus to the middle cuneiform. Bilateral arthrodesis of the interphalangeal joint of the hallux was performed and, on the left foot, osteotomy of the base of the first metatarsal. The fusions solidified in good position and the transplants worked well. In 1948, it was noticed that asymptomatic hammer toes had developed. When last seen in 1951, he was working without restriction of activity as an architect's draughtsman.

This was a characteristic case of the non-progressive type; the main disability was caused by foot deformity. Correction of the foot defect allowed full activities. A further case with a shorter follow-up period merits special presentation as an illustration of the unusually widespread and diffuse manifestations of the disease and the possibilities of surgical rehabilitation.

First seen in 1944, A. M., an eighteen-year-old male, had for five years noted a progressive peculiarity of gait, with a tendency to stumble. Examination showed a tendency to stagger and a high-stepping gait. Except for the calf muscles, all the foot muscles were weak. Both hands showed marked wasting of the intrinsic muscles and weakness of opposition. Neurological examination revealed that the knee jerks were weak; ankle jerks were absent; there were bilateral Babinski plantar responses; well marked nystagmus; ataxia; and loss of vibration sense in the legs. The patient failed to report to the Hospital during the next four years.

In 1948 he reappeared, complaining that for the past eight months his stance had been insecure. By then, the power of all dorsiflexors and plantar flexors of both feet was rated either weak or absent. The patient tended to move backwards in order to maintain his balance when standing and walked with drop-foot gait. For the past two or three years, he had noticed weakness of both hands and now lacked effective grip, due to inadequate thumb opposition.

In 1948, a left pantalar arthrodesis was performed, as well as a right opponens transplant, the flexor sublimis of the fourth finger being used. One month later, a right pantalar arthrodesis was carried out, and one month after this, a left opponens transplant was performed, the flexor sublimis of the fourth finger being used. As a result of these primary procedures, a pseudarthrosis occurred at the right ankle joint, and the right sublimis transplant did not work satisfactorily, producing hyperextension at the metacarpophalangeal joint. A year later, re-fusion of the right ankle joint was undertaken, as well as revision of the right sublimis transplant. Both of these procedures were successful. The patient was last seen three years following operation, in 1951. He was working full time in a carton factory, where a good deal of activity and prolonged standing were required. The patient walked without noticeable limp and, despite his bilateral pantalar arthrodesis, enjoyed hiking and frequently walked up to two miles. His hands exhibited good power and a strong grip. This result is rated as excellent and the patient is very grateful.

This case exhibited unusually widespread distribution of muscle paralysis and an excellent functional result from radical surgery. Here complete, even if temporary, rehabilitation was achieved.

OPERATIVE COMPLICATIONS AND SEQUELAE

Complications were few and no deaths resulted from operation. In one case bronchopneumonia developed postoperatively, but was resolved without ill effect.

There were three cases of serious postoperative wound infection. In each case the infection cleared and final healing occurred only after months of therapy, so that the normal postoperative course was prolonged. As a result of an incorrectly applied plaster cast, one patient incurred a pressure ulcer under the head of the first metatarsal. This healed after eight weeks.

In one case, following triple arthrodesis, a foul trophic ulceration developed under the head of the first metatarsal. A year after operation, the patient had a persistent chronic ulcer under the ball of the foot. At this point she left our care and did not return.

There was one case in which paralysis of the common peroneal nerve resulted from the application of a mid-thigh tourniquet. No recovery of function ensued and two years later an ankle fusion was performed to correct the drop-foot deformity and to secure a pantalar arthrodesis.

In each of three cases, a talonavicular pseudarthrosis resulted following a subtalar stabilization, and in another, a pseudarthrosis developed after attempted fusion of the ankle joint. In all four instances the pseudarthroses were repaired successfully. In another case, after a Naughton Dunn procedure, there was failure of talocuneiform fusion. As this was asymptomatic, no further operative interference was advised.

Fusion of the interphalangeal joint of the hallux was performed routinely, following extensor hallucis longus transplantation. Of twenty-one patients in whom this was done, two later showed malposition of the hallux and two showed asymptomatic pseudarthroses.

Serious recurrent varus of the foot occurred postoperatively in two patients, necessitating revision of the triple arthrodesis. In one of these cases, three revisions were required. In one case, an osteotomy at the base of the first metatarsal had to be repeated in order to eradicate marked drop of the fore part of the foot.

END RESULTS

Of forty-five patients who underwent operative procedures, seven were lost to further study; three have been operated upon within the past year and their results cannot yet be assessed; and one patient died in a mental institution seven years after the operation. Thirty-four thus remain for follow-up study and assessment of end results. Eight patients were followed for more than ten years; ten for between six and ten years and sixteen for periods between one and five years. The average period of follow-up was 7.2 years.

End results, in so far as it is possible to assess these in a disease of the progressive nature of Friedreich's ataxia, are here classified as anatomical and functional.

Anatomical

Five cases showed mild recurrent varus of the heel, which was insufficient to justify further interference; three showed mild persistent equinus, and three showed cavus. In all these cases, failure to obtain adequate correction was essentially a failure of surgical technique and was not due to intrinsic disease factors. In seven cases, clinical examination revealed a definable talotibial instability following subtalar arthrodesis but without interference with normal function.

Of eighteen cases in which the extensor digitorum longus was transferred, hammer toes with clavi subsequently developed in sixteen. Eight of these underwent arthrodesis of the proximal interphalangeal joints of the small digits for correction of this deformity. The mechanism is not difficult to understand. The action of the long toe extensors being nullified by their transplantation; that of the short extensors paralyzed by division of nerve supply (consequent to the lateral Hoke type of approach); and the interossei and lumbricales which normally extend the interdigital joints being weakened or paralyzed, the long toe flexors are unopposed and act as toe deformers.

Functional

Full functional activity was enjoyed by twenty-two of the thirty-four patients. Most of these patients avoided athletic activities, but were not otherwise restricted, and many lead full and useful lives. Three patients had entered the Armed Services: one after spine fusion from the fifth thoracic to the first lumbar vertebra for scoliosis, and two after bilateral triple arthrodeses with tendon transplants. The patients included a mechanic, who stood for eight hours daily, a painter, an architect's draughtsman, a beautician, an elevator operator, and a nineteen-year-old girl who, in her own words, "worked all day and danced all night". All patients in this group were grateful for the operation and satisfied with the results.

Improvement, but with moderate restriction of activities, was shown in eight cases. As a result of operation, these patients now enjoy improved gait, increased mobility, and widened activities, but they are restricted by their ataxia and muscle weakness.

One patient, five years after bilateral triple arthrodesis, became bedridden and has since remained so. Another, nine years after operation, is housebound because of general muscle weakness and ataxia. The two cases of functional failure have been described under Operative Complications and in Case 4, respectively.

SUMMARY

The locomotor disturbance present in Friedreich's ataxia is due to inherent neurological factors and to musculoskeletal disabilities. Structural foot deformities and instability are frequently responsible for abnormalities of gait and stance. These physical factors may be causes of dysfunction as significant as the ataxia itself.

While there is no known treatment for the fundamental disease process, prevention and adequate correction of foot deformity aids normal locomotion, prolonging the patient's mobility, delaying the day he must eventually become bedridden, and even lengthening his life span.

In the abortive or non-progressive type of Friedreich's ataxia, surgical correction of the deformity is of permanent value. In the progressive type, although surgical intervention may not basically alter the natural pattern of the disease, the period of normal activity is likely to be extended for many years.

It is emphasized that the general reluctance to undertake surgical correction of deformity is unjustified; that the risks involved are no greater than in other cases presenting similar deformities; and that the correction of the deformity has a markedly beneficial effect on the ataxia.

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THE MÖBIUS SYNDROME *

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The essential features of the Möbius syndrome are as follows:

1. Unilateral or bilateral loss of abduction of the eyes;
2. Unilateral or bilateral complete or incomplete facial weakness;
3. Primary or secondary congenital anomalies of the extremities;
4. Possible other involvement of the branchial musculature.

The condition is usually diagnosed during the first few days of life because of the incomplete closure of the eyelids during sleep and because of the difficult nursing. Also noticed is the masklike facial expression while the infant is crying or laughing, associated with dribbling saliva, depending on the degree of involvement of the facial musculature. Credit for the first description of the condition is given to Albrecht von Graefe; however, the condition was correlated into a group of constant symptoms by Möbius in 1888 [32] and goes under his name. Other early reports on the condition were those by Harlan in 1881, Chisholm in 1882, and Schapringer in 1889.

There seems to be no hereditary or familial tendency in true cases of the Möbius syndrome. However, the cases of facial diplegia reported by Webber, Trautmann, and Thomas show a definite familial tendency but no hereditary tendency.

The author wishes to add three cases of his own to the literature on the Möbius syndrome.

CASE 1. Richard W., a seven-year-old boy, was the only child of normal parents. The pregnancy, labor, and delivery had been normal, and there was no history of congenital defects on either side of the family. The following deformities were noted at birth: simple syndactylism of all fingers of both hands; bony ankylosis of the proximal interphalangeal joints of the middle finger and fibrous ankylosis of the distal joints of the same finger bilaterally; bilateral equinovarus with a marked cavus, more severe on the left; fibrous ankylosis of all interphalangeal joints of the toes; and syndactylism of all toes. The following neurological findings with respect to the cranial nerves were noted:

Third Nerve:
Weakness of the medial recti, with complete inability to adduct the eyes;
Weakness of the inferior rectus on the right.
Sixth Nerve:
Complete loss of abduction of the eyes.

FIG. 1-A

FIG. 1-B

Case 1

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Seventh Nerve:
Complete loss of the muscles of facial expression;
Inability to close eyelids completely.
Ninth Nerve:
Weakness of elevation of the soft palate;
Sluggish gag reflex.
Tenth Nerve:
Marked dysarthria on the basis of weakness of the laryngeal and pharyngeal musculature.
Eleventh Nerve:
Weakness of left sternocleidomastoid muscle as compared with the right.
Twelfth Nerve:
Marked atrophy of the left side of the tongue; on protrusion the tongue points to the left.
All forms of sensation carried over all cranial nerves were normal.

Case 2. Nancy N., a five-year-old girl, was the youngest of a family of four children. The parents, two brothers, and one sister were normal, and there was no familial history of congenital defects. The pregnancy, labor, and delivery had been normal. Deformities noted at birth were: a severe equinovarus club-foot deformity on the right; the left foot showed failure of complete development of the three lateral metatarsal rays and an absence of all the phalanges. The following neurological findings in the cranial nerves were noted:
Third Nerve:
Complete loss of function of the medial rectus bilaterally, with inability to adduct the eyes.
Sixth Nerve:
Complete loss of abduction of the eyes.
Seventh Nerve:
Absence of frontalis-muscle action bilaterally. Eyelids sluggish, more marked on the left. The right lower quadrant of the face was normal; function in the left lower quadrant was absent except for the rhisorius, which had only moderate function.
Twelfth Nerve:
Atrophy of the left side of the tongue; tongue protrudes to the left.
All forms of sensation carried over all cranial nerves were normal.

Case 3. Melvin C., a six-year-old boy, was the only child of normal parents. There was no familial history of congenital deformities. Pregnancy, labor, and delivery had been normal. The following deformities were noted at birth: There was severe microdactylia of all four fingers of the right hand; absence of all the meta-

Fig. 1-C

FIG. 2-A

FIG. 2-B

Case 2

carpals and all the phalanges of the fingers of the left; the left thumb was present but small; three rudimentary nails were present on the dorsum of the deformed hand. The lower extremities showed bilateral external tibial torsion. There was club-foot on the right with absence of all the phalanges and distal ends of the metatarsals. The remaining portion of the foot was in equinovarus. The portion of the left foot distal to the mid-tarsal joint was absent. The tarsus was in equinus. The remainder of the examination was within normal limits except for the following neurological findings in the cranial nerves:

Second Nerve:

Patient wears corrective lenses for myopia and astigmatism.

Third Nerve:

Complete loss of adduction of the left eye.

Sixth Nerve:

Complete loss of abduction of both eyes.

Seventh Nerve:

Complete absence of function of the muscles of facial expression with the exception of the right side of the orbicularis oris.

All forms of sensation carried over all cranial nerves were normal.

Faradic and galvanic stimulation procedures were carried out on all three patients, with the following results:

In Case 1, there was no response in any part of the facial musculature to stimulation of the motor points of the muscles themselves or to stimulation of the branches of the facial nerve.

In Case 2, stimulation of the facial-nerve trunk produced contraction of all the muscles of the lower quadrant on the right side. There was no response on the left and no response from stimulation of the frontalis or the upper facial branch on either side.

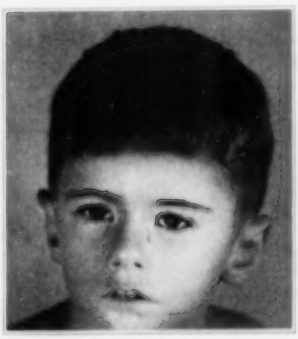

FIG. 3-A

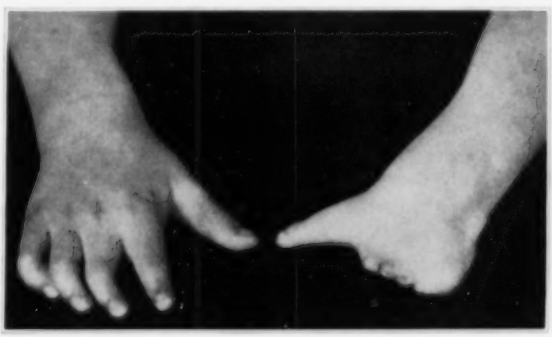

FIG. 3-B

Case 3

FIG. 3-C

In Case 3, stimulation of the facial-nerve trunk produced mild puckering of the orbicularis oris bilaterally. There was no response from stimulation of the upper branch on either side.

Biopsy of the frontalis muscle was performed on each of these children because of the consistent absence of function bilaterally. Grossly there was no muscle to be seen and no evidence of muscle remnant or of degenerated muscle was found. The histological report in all cases was consistently "no muscle tissue".

DISCUSSION

Seventy-two cases of the syndrome of congenital facial diplegia are reported in the literature. Of these, forty-five are true examples of the Möbius syndrome, which includes the associated anomalies of the upper and lower extremities. In eight cases there were deformities of both upper and lower extremities; in twenty-one cases there were deformities of the lower extremities. There seems to be a definite correlation between the degree of paralysis of the sixth and seventh nerves and the severity of the deformities in the extremities. Of the eight patients showing deformities of both upper and lower extremities, six had bilateral upper and lower facial paralysis and bilateral sixth-nerve paralysis.

Möbius suspected that the underlying pathological condition was "*infantiler Kernschwund*", or degeneration of the nuclei of the sixth and seventh nerves. Kunn, however, believed it to be a nuclear aplasia. Heubner believed that it was a brain-stem hypoplasia.

Heubner, in 1900, presented the first concrete pathological data in the form of an autopsy report of a child aged two years. He noted the following clinical findings: bilateral sixth-nerve paralysis; complete paralysis of the seventh nerve on the left, incomplete paralysis on the right; and atrophy of the left anterior half of the tongue. The postmortem findings showed a complete absence of the nucleus of the sixth nerve and a diminished number of normal cells replacing the normal nucleus of the seventh nerve. The nerve roots were small or absent. There was aplasia of the left pyramidal tract and olivary body. The left posterior longitudinal bundle and left reticular substance were poorly developed.

In 1903 Rainy and Fowler performed an autopsy on a child ten weeks of age who had complete bilateral facial-nerve paralysis without other cranial-nerve involvement. The histological report showed cell degeneration rather than aplasia of the cells of the seventh-nerve nucleus bilaterally. The nerve fibers were present, but also showed evidence of degeneration.

In 1907 Neurath reported an autopsy, which he did not himself attend, on a child six weeks old who showed seventh-nerve involvement on the right side and some involvement of the extremities. The nucleus of the seventh nerve was normal bilaterally, as were the facial nerves.

Lennon, however, interjected an entirely new pathological concept. While Möbius, Kunn, and Heubner, although not agreeing on the specific nature of the process, all considered the lesion to be a defect in the formation of the ectoderm resulting in failure of nuclear and later nerve-tissue formation, Lennon quoted the work of Schenke, Obersteiner, and Abromeit, and suggested that the pathology might consist primarily in a defect in the

mesoderm, with a failure of development of the muscles, and a secondary underdevelopment of the nerves and nerve nuclei.

Abromeit made the following classification of the anatomical nature of these defects:

The first group consisted of those cases in which no embryological formation of muscle ever existed, — that is, in which no evidence of muscle tissue was found.

The second group consists of those cases in which the muscle was laid down, but underwent degeneration during the period of development, because of failure of development of the nerve supply to the organ. In these cases there is evidence of the earlier independent existence of muscle tissue in the form of tendinous and fatty tissue. In this group the condition may result from the following: (1) lack of union of the nerve and muscle; (2) lack of development of the nerve; and (3) defective development of the nuclei.

Schenke demonstrated a case of ophthalmoplegia in which the ocular muscles were absent, but the nerve and ganglion cells were intact. Mittendorf and McDannald have also demonstrated absence of the muscles at operation.

Obersteiner dissected the cord of a man who lacked from birth most of the large muscles of the right shoulder girdle and the right side of the neck. He found the corresponding segments of the cord to be intact. In contrast to this, Edinger reported total atrophy of the corresponding anterior horn cells in a case of intra-uterine forearm amputation.

Marfan and Armand-Delille, whose autopsy report showed degeneration of the seventh-nerve nucleus, were of the opinion that the primary defect was in the temporal bone; this led to interference with the nerve development and to secondary degeneration of the nucleus. The existence of the intracranial portion of the nerve indicated a purely peripheral type of lesion.

Rainy and Fowler felt that the presence of nerve trunks in their case, even though degenerated, was positive proof of earlier existence of nuclei from which they arose.

According to Lennon, the various hypotheses of the etiology in Möbius' syndrome may thus be summarized as follows: (1) The condition is due to a primary aplasia or agenesis of muscle,—that is, to a mesodermal defect; (2) it results from interference with nerve growth; (3) it is due to nuclear agenesis,—that is, an ectodermal defect; (4) it is due to nuclear aplasia, an ectodermal defect.

Bonnevie in 1934, using Little and Bagg's abnormal mice in which deformities had been initiated by exposure of the pregnant mothers to x-ray, inbred a strain of mice with eye and limb deformities. She claimed to have found an excessive production of cerebrospinal fluid, as well as collections of this fluid in subcuticular vesicles on the back of the neck. Under pressure the fluid migrated to the orbital regions and to the ends of the limbs. Here it produced hemmorhage and hematoma formation and subsequent deformities.

Warkany [44] in 1943 produced primary congenital deformities of the extremities and jaw in newborn rats whose mothers had been fed on a riboflavin-deficient diet. These deformities were rather consistent; they involved the mandible, which was shortened, the upper extremity, where shortening or absence of the radius and ulna resulted, the lower extremity, where shortening or absence of the tibia and fibula were found, as well as the trunk, where the most consistent deformity was fusion of the ribs.

Pursuing the theory of the congenital absence of muscles as the most tenable theory of the etiology of the Möbius' syndrome, we find that the most complete work on this subject was done by Bing.

In summarizing the cases of congenital absence of muscles reported in the literature, we note that the pectoral muscles have been found to be the most frequently absent, and have been so reported in 102 cases. Additional reports show absence of the trapezius, quadriceps, serratus magnus, and semimembranosus. Very few histological studies have been made in these cases. In some, however, the motor neurons in the corresponding segments of the spinal cord were found to be diminished or absent, but in most cases no significant changes in the neuron systems were discovered.

CONCLUSIONS

The most consistent weakness in the previously reported cases was the lack of a complete and accurate neurological examination by the clinician. Where autopsy material has been available, there has been a lack of microscopic cell and filament counts in and about the brain-stem nuclei. As regards older reports, it is realized that facilities for doing accurate histological examinations were not as great as they are at the present time, especially in view of the greater number of stains and counterstains available to the present-day pathologist. Biopsy material and evaluation of the electrical responses of the facial nerves and muscles also were not obtained in the past.

The following facts are presented in an effort to establish an etiological trend:

1. If the condition is considered to be entirely neurological in origin, several discrepancies which arose in the examination of the cranial nerves must be explained.

a. In none of the examinations in the three cases here presented was there any sensory loss over the distribution of the cranial nerves.

b. The oculomotor-nerve involvement is consistently incomplete, with preservation of function of the medial rectus and absence of function of the remaining recti (superior and inferior) and of the inferior oblique.

c. The facial musculature offers a confusing picture, since in a peripheral type of unilateral facial-nerve paralysis the overlap innervation of the frontalis muscle preserves the function of the frontalis muscle on the involved side, whereas in the central type of lesion—that is, above the nucleus—this overlap innervation is obliterated and the entire face is paralyzed. In these cases of Möbius' syndrome, however, the upper quadrants of the face are always involved, either unilaterally or bilaterally and, if any facial expression remains, it is always in the lower quadrants. This would be impossible to explain on the basis of a neurological lesion.

d. The electrical examination, both galvanic and faradic, at the motor points of the facial nerves and muscles indicates definitely that the nerves are present and functioning. Stimulation of the main facial-nerve trunk in one case in which the facial musculature of the upper quadrant was functionless and that of the lower quadrant was voluntarily active resulted in contracture of the muscles in the lower quadrant only.

2. It is impossible to implicate a definite period of time as that when failure of development would hinder the development of both the cranial-nerve nuclei and the extremities. A correlation can be made, however, between the stem tissue of the extremities and the branchial musculature, both being of mesodermal origin, while the cranial-nerve nuclei are of ectodermal origin.

3. In the syndrome of facial diplegia, which consists of paralysis of the sixth and seventh nerves only, a small lesion of the brain stem can easily explain the clinical findings. In the Möbius syndrome, however, which often includes involvement simulating other cranial-nerve lesions, as well as the malformations of the extremities, the intracranial lesions would certainly have to be multiple, and many of them would have to be incomplete to explain satisfactorily the preserved sensory apparatus and the partial motor involvement.

4. The most important conclusion to be drawn from the information presented in this paper is based on the pathological reports. In none of these reports was there any evidence of normal muscle, degenerated muscle, or remnants of pre-existing muscle. In none of the previous autopsy reports which showed absence or degeneration of the cranial-nerve nuclei was there any mention of the status of the facial musculature. For this reason, the author would agree with Lennon's explanation of the etiology, which assigns the condition to a mesenchymal defect,—that is, absence of muscles with secondary failure of development of the nerves and ultimate degeneration of the nuclei as a result of disuse.

One of the most important orthopaedic conditions of unknown etiology to be kept in

mind in any theory on the etiology of the Möbius syndrome is that of arthrogryposis multiplex congenita. J. R. Moore has pointed out that the Möbius syndrome may be arthrogryposis which is limited to the facial musculature, both stemming from a primary mesenchymal defect. For this reason, if the opportunity should arise to perform an autopsy in either type of case, a thorough histological examination of the musculature, peripheral nerves, cord, and brain stem should be performed.

Certainly all the findings in these children can be more easily and scientifically explained by Lennon's theory than by a theory which would presuppose primary, multiple, complete, and incomplete nervous-system lesions.

NOTE: The author wishes to express his appreciation to the Philadelphia Unit of the Shriners' Hospital for Crippled Children for permission to publish the cases presented herein, and to the Surgical Staff of the Hospital for its guidance in the preparation of this paper.

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MULTIPLE LESIONS OF BONE IN LETTERER-SIWE DISEASE

Report of a Case with Culture of Paracolon Arizona Bacilli from Bone Lesions and Blood, Followed by Response to Therapy

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An unusual case of clinical Letterer-Siwe disease has presented an opportunity to investigate the development and manner of healing of the bone lesions and has revealed what appears to be the causative organism.

The patient presented roentgenographic evidence of multiple destructive and productive lesions of the long bones, skull, and ribs, associated with generalized lymphadenopathy, fever, rapid pulse, anaemia, and slightly depressed white count; the condition assumed a progressive course which in eight months brought the patient close to death from a clinical syndrome which seemed most compatible with Letterer-Siwe disease.

The patient responded dramatically to antibiotic therapy. This is the fifth known case during the past two years of Letterer-Siwe disease in which clinical healing was obtained by intensive treatment with antibiotics.

Over the course of a year, six different surgical biopsies were done, each from a previously untouched bone lesion. Three of these biopsies were done during the active stage of the disease, while the other three were made during the healing stage. The original biopsy showed non-lipid histiocytosis compatible with Letterer-Siwe disease. The second biopsy showed the development of a lipid histiocytosis. The blood culture and tissue cultures revealed paracolon bacilli of the Arizona group.

This case is reported in detail, as it appears that it is the first in which a definite organism has been associated with Letterer-Siwe disease or a process closely resembling it.

CASE HISTORY

A two-year-old colored male was admitted to Medical College of Virginia Hospital on June 12, 1951, with a history of not being able to walk for the preceding month. Eight weeks before admission, a "kernel" had developed in the left cervical region, together with fever and fretfulness. A few days later, it had been noted that he was limping on the left and shortly after that the parents had noticed a swelling over his right forearm and left leg. The pain and swelling had increased to the extent that walking had been impossible for a month. When he was finally taken to a physician, he was found to have a temperature of 103 degrees and was referred to the Hospital for diagnosis and treatment.

Past History

The patient had weighed six pounds at birth after an easy, normal, spontaneous delivery. He had been bottle-fed and had never had cod-liver oil. His general health had been good until the onset of the present illness, except for measles at three months of age and chicken pox three months before admission. The patient had had "sniffles" and a cough during the two weeks before admission and four loose stools daily for one week instead of the usual one or two stools a day.

Family History

The father was twenty-three years of age and the mother nineteen. Neither had a history of tuberculosis, syphilis, or other disease. There was one four-month-old sister, who was living and well. The family lived with other people in a crowded house on a small farm with its own raw-milk supply.

Physical Examination

Upon admission the patient's temperature was 100.6 degrees; the pulse was 140, respiration 28. The general appearance was that of a fairly well developed, somewhat undernourished two-year-old colored male who was extremely irritable and cried almost continually. The skin was warm and moist, and there were a few depigmented areas over the trunk, apparently a residuum of chicken pox. The head revealed a palpable one-inch defect of the calvarium in the parietal region. The heart and lungs were normal. The liver, kidneys,

FIG. 1-A
June 1951

FIG. 1-B
December 1951

FIG. 1-C
June 1952

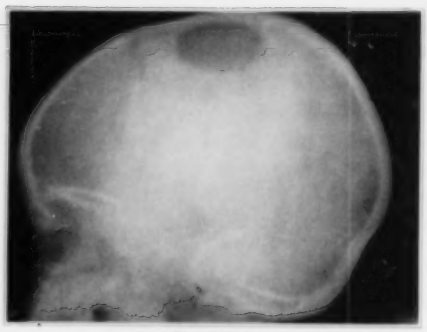

FIG. 2-A
June 1951

FIG. 2-B
December 1951

FIG. 2-C
June 1952

Figs. 1-A, 2-A, and 3-A show the lesions on admission in June 1951.

Figs. 1-B, 2-B, and 3-B show the process at the height of the disease in December 1951.

Figs. 1-C, 2-C, and 3-C show the healing of the disease in June 1952.

and spleen were not palpated. Moderate-sized, shotty lymph nodes were present in the anterior and posterior cervical regions, in the axillae, and in the inguinal region. The chest revealed a rather indurated subcutaneous mass, which was tender but not fluctuant, in the left anterior axillary line, apparently arising from one of the lower ribs. There were tender, indurated swellings of the tibia, most prominent below the knee on the left and above the ankle on the right. There was also a mass over the distal end of the right radius similar to the tibial lesions. The patient had pain when examination of these areas was carried out, although no fluctuation was present in any of these lesions, nor was motion limited in any of the joints. The patient could crawl with an effort, but would not stand by himself.

Roentgenograms (Figs. 1-A, 2-A, 3-A, and 4-A) of the skeletal system revealed seven lesions in the

FIG. 3-C
June 1952

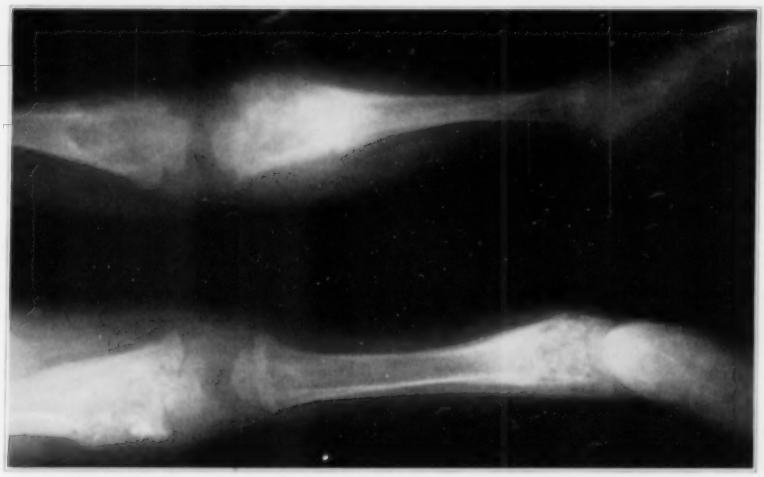

FIG. 3-B
December 1951

FIG. 3-A
June 1951

FIG. 4-A
Showing lesion on admission, June 1951.

FIG. 4-B
Showing healing in June 1952.

metaphyseal regions of the long bones, two in the ribs, and one in the skull. The lesions in the metaphyseal areas were characterized by an extensive destructive process with marked reactive periosteal new-bone formation, whereas the flat bones presented punched-out areas of destruction. The proximal portion of the left tibia, distal end of the right tibia, distal ends of both femora, proximal end of the right femur, proximal end of the left humerus, distal end of the right radius, the third and seventh left ribs, and the parietal region of the skull were involved. A chest roentgenogram showed prominent hilar nodes.

Laboratory findings on this first admission were as follows:

Red blood cells	3,380,000 per cubic millimeter
Hemoglobin	7.8 grams per 100 cubic centimeters
Platelets	970,180 per cubic millimeter
White blood cells	5,500 per cubic millimeter
Neutrophils	70 per cent.
Eosinophils	2 per cent.
Lymphocytes	26 per cent.
Monocytes	2 per cent.

A peripheral blood smear showed hypochromic microcytic anaemia with increased platelets. The sickle-cell test was negative.

A sternal-bone-marrow study showed myeloid hyperplasia with decreased erythroid activity, although with some increase in immaturity. The megakaryocytes were small but showed marked platelet production.

Routine agglutinations, including typhoid O, typhoid H, typhoid B, brucella, and proteus X_{19} were negative.

The Hinton test was negative.

Calcium	10 milligrams per 100 cubic centimeters
Phosphates	4.6 milligrams per 100 cubic centimeters
Alkaline phosphatase	5.1 Bodansky units
Total protein	5.5 grams per 100 cubic centimeters
Albumin	2.2 grams per 100 cubic centimeters
Globulin	3.3 grams per 100 cubic centimeters
Cholesterol	180 milligrams per 100 cubic centimeters

A spinal-fluid study showed no abnormalities. Examination of several stools was negative for ova and parasites.

Urinalysis was normal and there were no Bence-Jones proteins.

Three days after admission, biopsy was performed on the left tibia. Marked periosteal thickening was noted, as well as a very thin cortex, which could easily be cut with the scalpel. Beneath the cortex, grayish-

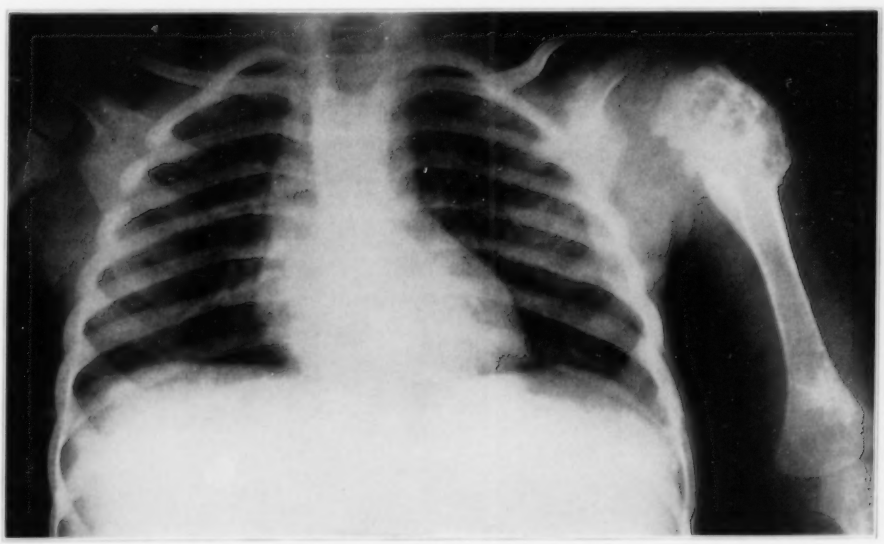

FIG. 5

Showing chest at height of the disease.

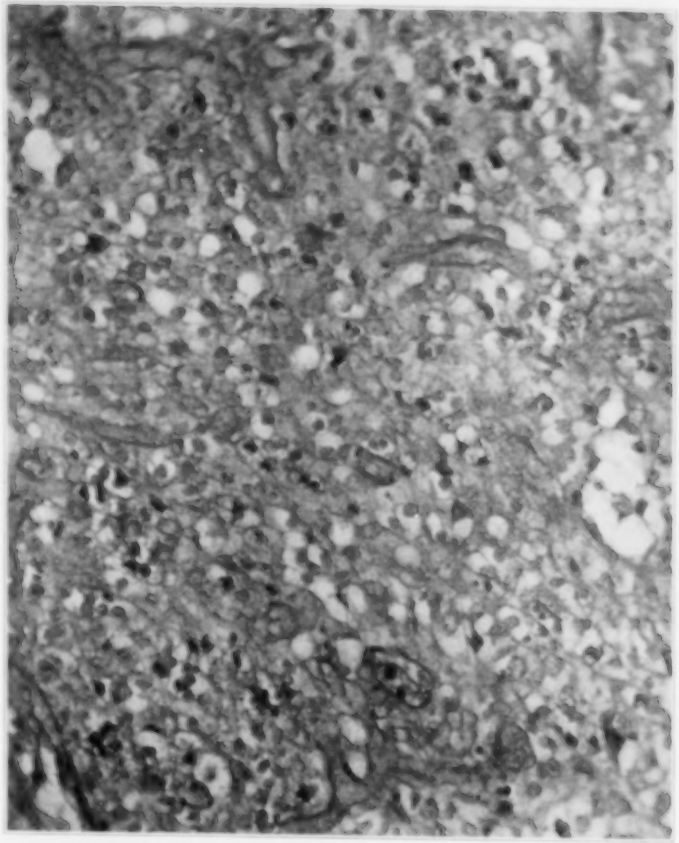

FIG. 6-A

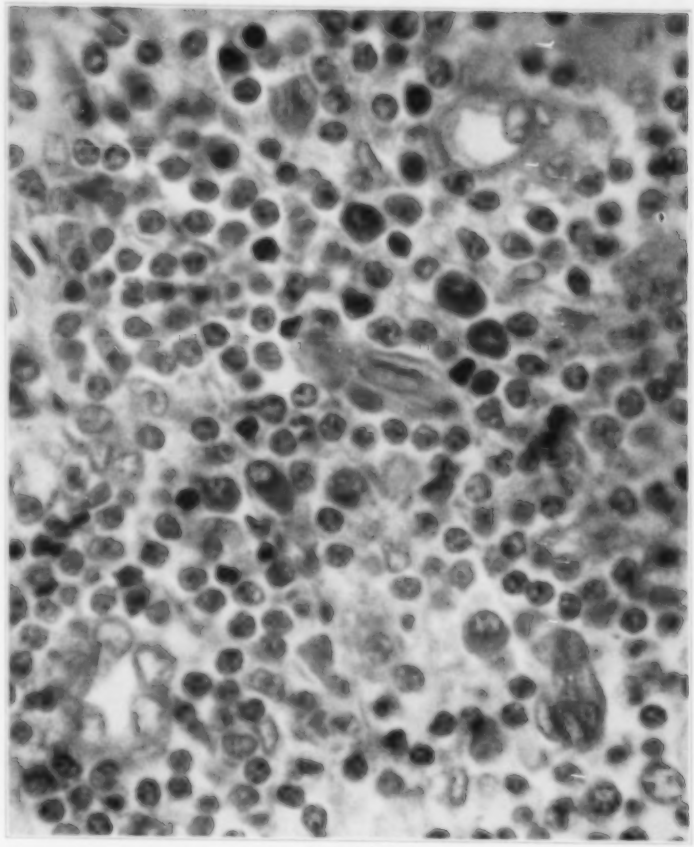

FIG. 6-B

Fig. 6-A: Showing an area with numerous non-lipid histiocytes from the first biopsy in June 1951 (× 550).
Fig. 6-B: Showing an area of inflammatory cells: plasma cells, neutrophils, lymphocytes, and a few dark-appearing eosinophils (× 1000).

white, soft, jelly-like granulation tissue was present, which was easily scooped out with a curette. The granulation tissue blended into the rather porous adjacent bone.

The microscopic report noted that there was present a cellular fibrous connective tissue massively infiltrated with lymphocytes, plasma cells, and polymorphonuclear leukocytes, some of which were eosinophils (Fig. 6-B). There was a prominence of histiocytes (Fig. 6-A), but lipid-containing cells were not noted.

A diagnosis of Letterer-Siwe disease was made on the basis of the clinical course and the histological pattern of the biopsy.

After the biopsy, penicillin and chloromycetin were given prophylactically for three weeks. The general condition of the patient improved somewhat following this therapy, which also included a transfusion. The temperature during this time ranged between 99 and 102 degrees, the pulse between 120 and 160. During antibiotic therapy, there was a noticeable gradual decline in the temperature and pulse.

In view of the widely held opinion that Letterer-Siwe disease is fatal and that no type of therapy is of much value, the patient was discharged with a poor prognosis on July 3, 1951, to be followed in the Out-Patient Department.

The case record and slides were sent to Dr. Lent C. Johnson of the Armed Forces Institute of Pathology to be reviewed after the patient's discharge. We received the following report:

> "After the correlation of x-rays and microscopic slides with the clinical history, the staff believes the patient has a low-grade osteomyelitis affecting multiple bones and caused by one of the rarer, very mild pathogenic organisms. Two organisms which might produce such a low-grade inflammation and involve many bones are some of the unusual strains of Salmonella and granuloma inguinale. This diagnosis does not in any way interfere with the two other possibilities which you suggested, namely, eosinophilic granuloma and Letterer-Siwe disease. It is believed that both are the result of low-grade inflammatory organisms which rarely, if ever, are isolated. The bones of infants are very different from the bones of children and adults in their reaction to such low-grade organisms. Hence, the x-rays may produce startling signs of abnormality when the clinical symptoms are relatively mild. The typical symptoms of Letterer-Siwe disease might later develop, or some of the lesions which are clearly inflammatory as shown by the present biopsy could, at a later date, develop the histological picture of eosinophilic granuloma."

Following this report, we re-admitted the patient on August 24, 1951, for further studies.

The general condition had changed very little, the same physical findings being present as on discharge. The temperature was 100 degrees, the pulse 100, and respiration 32. A search for further evidence of visceral involvement again revealed the moderately enlarged lymph nodes in the submandibular, axillary, and inguinal regions. The liver and spleen were not palpable, and no purpuric spots or skin lesions were noted. It should be noted that examination of the abdomen was unsatisfactory, because of the patient's crying and irritability.

The roentgenograms showed further progression of the destructive lesions in the bone, but no additional lesions were noted. A chest roentgenogram showed a large density at the hilum, "suggesting nodes".

Laboratory findings on this admission were as follows:

Red blood cells	3,900,000 per cubic millimeter
Hemoglobin	8.7 grams per 100 cubic centimeters
Platelets	2,500,000 per cubic millimeter
White blood cells	9,700 per cubic millimeter
Neutrophils	70 per cent.
Lymphocytes	29 per cent.
Monocytes	1 per cent.
Sedimentation	60 millimeters per hour (Wintrobe method)
Calcium	13 milligrams per 100 cubic centimeters
Phosphorus	6.4 milligrams per 100 cubic centimeters
Phosphatase	8.4 Bodansky units
Cholesterol	220 milligrams per 100 cubic centimeters, with 70 milligrams per 100 cubic centimeters in ester form

The urinalysis was normal.

Stool cultures specifically made for organisms of the Salmonella group revealed none. A blood culture

made on this admission was reported by the laboratory as having grown out gram-negative bacilli with the same fermentation and cultural characteristics as those of the Salmonella group!

On August 29, 1951, a biopsy of the distal end of the right tibia showed the lesion to be almost indistinguishable from that revealed at the previous biopsy. Copious amounts of grayish-white, soft granulation tissue were easily curetted from within the lesion. The abdomen was examined under anaesthesia; the liver was palpated two fingerbreadths below the costal border, but the spleen was not felt.

The laboratory reported that each of the two specimens obtained from the biopsy, including blood from the operative area and granulation tissue, likewise had grown out gram-negative bacilli. All three cultures were sent to Dr. P. R. Edwards at the Communicable Disease Center in Atlanta, Georgia, for further identification and typing. He reported that all cultures showed organisms identified as paracolon bacilli of the Arizona group with the antigenic formula Ar.5: 13, 14 and with fermentation of lactose in three days.

The microscopic report of the tissue removed at biopsy noted that the same inflammatory cells as those previously noted were present, — namely, lymphocytes, plasma cells, and leukocytes with some microsequestra. The most notable differences were the presence of areas with histiocytes containing lipid material (Fig. 7) and a notable increase in the number of eosinophils.

Antibiotic sensitivity tests were carried out for the paracolon bacilli. Streptomycin was most effective, with chloromycetin and terramycin following in that order. Penicillin was not effective in inhibiting the bacteria. A course of specific antibiotic therapy was planned, 0.3 grams of streptomycin being given the patient twice daily for a period of nine and one-half weeks. The patient did not respond and the temperature elevations ranged from 99 to 102 degrees during this period. His pulse remained elevated, frequently from 120 to 140. Clinical and roentgenographic evidence showed that the bone lesions continued to enlarge despite treatment.

By December 1, 1951, seven months from the onset of the symptoms, his condition had become quite grave. A large mass of nodes had developed in the right side of the neck and all bone lesions had increased considerably in size (Figs. 1-B, 2-B, 3-B, and 5). The right wrist was three times the size of the left. The palpable skull lesion had increased to three and one-half inches in diameter. All who observed the patient felt that there was very little hope for his survival. He was critically sick, fretful, and anorexic, despite forced feedings, transfusions, and other supportive treatment.

Findings at the third biopsy, made on a specimen from the right radius on December 11, 1951, were

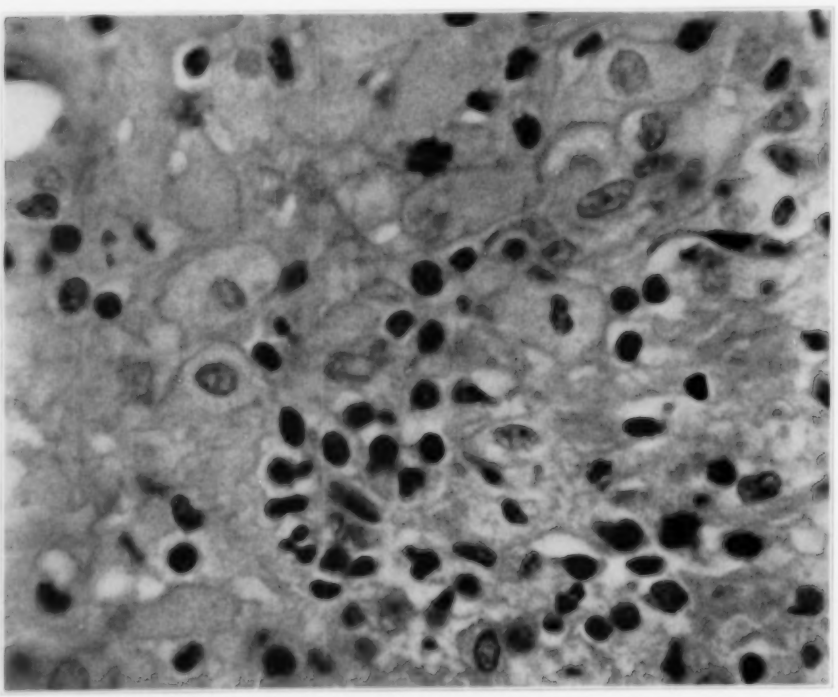

FIG. 7

Nest of lipid-containing histiocytes from the second biopsy in August 1951 (× 1000).

grossly identical with those of the first. The cultures of this tissue again revealed the paracolon bacillus, which indicated its presence in different bone lesions sixteen weeks from the time it was first cultured from bone. The microscopic report of the material from the third biopsy noted the same granulation-tissue response, with an apparent decrease in the number of eosinophils, lipid-containing and non-lipid-containing histiocytes. More prominent this time were micro-abscesses and microsequestra. There were numerous giant cells with irregular new-bone formation.

It was believed that the only chance for reversing the downhill course would be to try "shotgun" therapeutic measures. This consisted in the use of the antibiotics, chloromycetin and terramycin, together with roentgen therapy.

Chloromycetin, one-half gram every six hours, and terramycin, one-fourth gram every six hours, were started on December 11, 1951. Chloromycetin was continued until March 23, which constituted four months of treatment. Terramycin was continued from December 11 until February 7, at which time the patient began to have nausea. The drug was withdrawn and the nausea subsided. Roentgen therapy was started on December 12, 1951, and consisted of 25 roentgens daily until a total of 200 roentgens had been given, as measured in air. The liver and spleen were shielded by lead. Factors of this therapy were 200 kilovolts, 20 milliamperes, at a distance of 100 centimeters. A filter using 0.5 millimeter copper and 1.0 millimeter aluminum with a half-value layer of 1.0 millimeter copper was employed.

There was a dramatic, immediate response within one week of the newly instituted therapy. The temperature became normal and the pulse was lowered substantially (Chart I). With the exception of three days in the third week of the chloromycetin and terramycin treatment, the temperature and pulse remained within normal limits during a six-month period of observation. In addition both clinical and roentgenographic evidence showed that all bone lesions had subsided and become inactive (Figs. 1-C, 2-C, 3-C, and 4-B).

The laboratory studies have been of interest. The hemoglobin had risen from 7.8 grams on first admission to 9.6 grams on December 20, 1951. During this six-month period the patient had received a total of 725 cubic centimeters of blood from four transfusions. The hemoglobin went up to 13.6 grams, without any transfusions, four months after effective antibiotic therapy had been started.

The white-blood count, which had ranged between 5,500 and 9,700 for six months, rose to 19,200 on December 5, 1951, at the height of the disease. This elevated count promptly dropped to normal after a week of combined antibiotic therapy, as did the temperature. Differential counts have shown slight increases in the neutrophils, with eosinophils varying from 2 to 4 per cent. in the majority of the determinations. In July 1952 serological study demonstrated agglutination of the patient's own organism by his serum in a titer of 1 to 40.

The platelet counts of 970,180 and 2,500,000 per cubic millimeter are of special interest, as Siwe's original case was noted as having 1,400,000 platelets per cubic millimeter. In other reported cases, however,

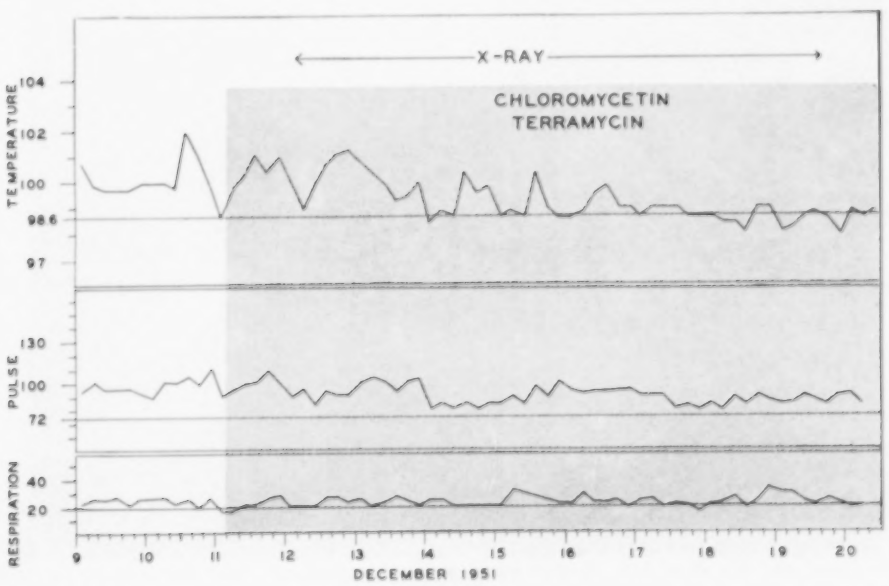

CHART I

Showing the drop of the temperature to normal during the first week of antibiotic therapy.

the platelet counts have been variable, actually more often lowered than elevated. No explanation for this is known, although one may speculate about the absence of purpura in association with these high counts.

The cholesterol-ester relationship did not vary from normal. The sedimentation rates (Wintrobe method) showed fluctuations, varying from 60 millimeters on August 29, to 4 millimeters on September 12, to 10 millimeters on September 15, to 30 millimeters on December 5, to 18 millimeters on January 19, to 12 millimeters on February 5, 1952. Alkaline-phosphatase determinations showed no elevations. A peripheral-blood smear on December 12, 1951, at the time of the third biopsy, showed a leukocytosis and a few band neutrophils with frequent segmenters. Toxic granulations and vacuoles were present. Platelets were numerous and were usually seen in large clumps. Pelvic-bone-marrow studies at this time showed a marked myeloid hyperplasia with slightly depressed erythroid formation. The lymphocytes and eosinophils were increased. Megakaryocytes were numerous, with marked platelet production. The concentrated-marrow studies showed a slight increase in fat and a cellular volume four times that of normal.

The fourth biopsy (Fig. 8) was done on February 20, 1952, ten weeks from the third, and was made on the distal end of the right femur; simultaneously a second specimen from the distal end of the right radius was obtained. Grossly there was a noticeable change in the structures of the lesions, as they appeared to be filling in with new bone.

There was some granulation tissue, but it was much less conspicuous than before. On April 2, 1952, six weeks after the preceding biopsy, another specimen was taken from the distal end of the left femur. Gross findings again were much the same as those of the fourth biopsy, in which there had been rather marked new-bone formation. On June 19, 1952, the sixth biopsy specimen was taken from the proximal end of the right femur.

The histological findings of the fourth biopsy, which was made two months after the administration of chloromycetin and terramycin, showed a conspicuous diminution of the granulation tissues and inflammatory cells which had characterized the active phase. New-bone formation was prominent, with scarring of the marrow spaces. The last two biopsies showed further healing by the appearance of more mature trabeculae in the areas of bone previously involved, as well as complete disappearance of the inflammatory reaction. The last biopsy showed that normal marrow structures were reappearing. All cultures, including six of blood and three of bone tissue, removed at biopsy, have been negative since administration of chloromycetin and terramycin was started.

Clinically, the areas of swelling over the bone lesions disappeared, and the previously mentioned skull lesion filled in. The mass of glands in the neck, as well as the generalized lymphadenopathy, receded. The liver was not palpable at the last biopsy, made under general anaesthesia.

The weight changes clearly showed the rapid recovery of the patient. On December 1, 1951, at the

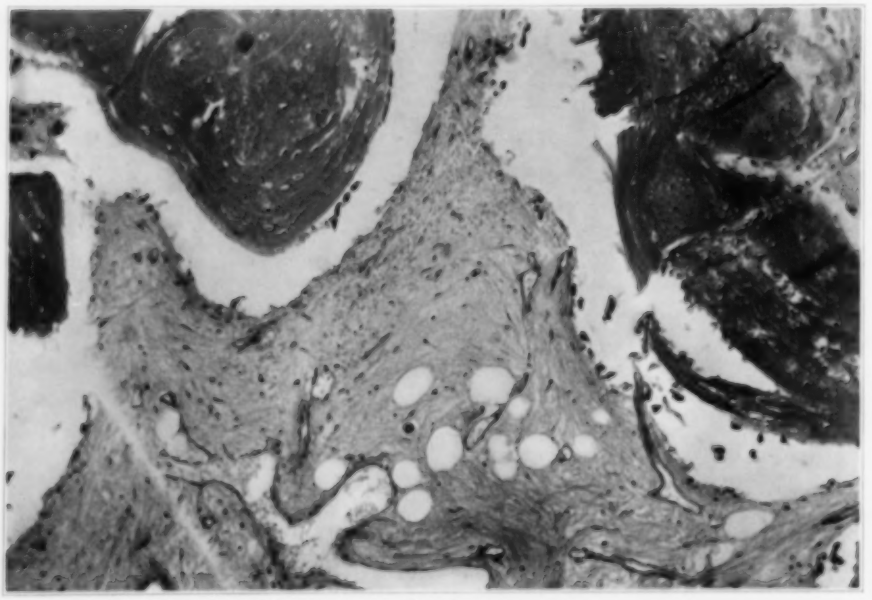

FIG. 8

Material from the fourth biopsy in February 1952, two months after therapy, showed scarring-in of the marrow spaces, new-bone formation, and absence of previous cellular components (× 175).

height of the disease, he weighed twenty pounds, thirteen ounces. On December 25, 1951, two weeks after the combined therapy had been instituted, he had gained five pounds. On June 8, 1952, the patient weighed thirty-five pounds, having nearly doubled his weight in six months.

The patient has been up and is very active. He has a mild valgus deformity of the left knee as a result of disturbed epiphyseal growth of the proximal end of the tibia; this is being conservatively treated with casts and a brace.

DISCUSSION OF THE CASE

The diagnosis of Letterer-Siwe disease was made in view of the progressive, febrile, near-fatal course of the disease characterized by lymphadenopathy, persistent anaemia, transient hepatomegaly, and multiple bone lesions. The microscopic findings of the tissues removed at biopsy showed the histological characteristics of Letterer-Siwe disease. Dr. Henry L. Jaffe, who reviewed the case record and slides, wrote after the first biopsy:

> "I believe you are dealing with a case of so-called Letterer-Siwe disease, a condition which is probably related to eosinophilic granuloma and Schüller-Christian disease. The clinical findings in your case are rather classical and many cases of Letterer-Siwe disease present multiple destructive osseous lesions."

This patient did not show splenomegaly or skin changes, which are so frequently described in cases of Letterer-Siwe disease. On the other hand, in view of the progressive lymphadenopathy and transient hepatomegaly, splenomegaly and purpura might well have developed had the downhill course not been reversed by antibiotics.

In any event, it is recognized that there may be variations of clinical involvement in this disorder. To illustrate, a case [9] was reported which at necropsy showed no hepatomegaly or splenomegaly, nor were there any significant microscopic changes in the liver or spleen. Another patient [7] showed no skin lesions except for a transient purpura for "three to four" days.

Likewise the fact that this case showed overlapping histological patterns consistent both with Letterer-Siwe disease and Hand-Schüller-Christian disease (a non-lipid histiocytosis developing into a lipid histiocytosis) conforms to the widely accepted concepts expressed by Wallgren, Jaffe and Lichtenstein, and others. Wallgren felt that the only essential difference between Letterer-Siwe disease and Hand-Schüller-Christian disease is a storage of cholesterol in foam cells in the latter. He stated that foam cells occur only in those cases in which the duration has been three months or more, and that they are always found if the disease has been present more than twelve months. He suggested that the lack of foam cells in Letterer-Siwe disease may be explained by its rapid termination, which does not allow sufficient time for their accumulation.

It is interesting to note that the foam cells were found to be present at the second biopsy, made four months after onset of symptoms; this supports Wallgren's observations.

Dr. Henry L. Jaffe described this transition after reviewing the second biopsy:

> "These sections show again the features of Letterer-Siwe disease. However, in these sections, one notes that many of the histiocytes now contain lipid, and in many places there is evidence of collagenization. The leukocytes are mainly eosinophils. There is, of course, evidence of inflammatory response as shown by the presence of numerous lymphocytes and plasma cells. This inflammatory response is part of the total cytologic picture of the condition. You are apparently dealing with a case of Letterer-Siwe disease, in which the inflammatory lesions are becoming lipidized and collagenized. Thus, you are dealing with Letterer-Siwe disease going on to show some of the histologic features of Schüller-Christian disease."

The role of the paracolon bacillus in this case might be interpreted in three ways: (1) This organism was an opportunist merely complicating Letterer-Siwe disease; (2) the case was one of paracolon osteomyelitis with multiple lesions simulating Letterer-Siwe disease; or (3) the case represents Letterer-Siwe disease produced by the paracolon organisms.

As to the first possibility, we feel that the evidence does not support this contention.

The fact that an unusual organism was recovered from the blood stream and from two different bone lesions at intervals of sixteen weeks is strong evidence against this theory, as opportunists do not possess such persistent characteristics. If the organism had been merely an opportunist, one would expect the symptoms of Letterer-Siwe disease to continue in spite of the eradication of the bacteria. However, there was complete regression of the lesions with clinical healing following therapy specifically directed against this organism, which indicates that the bacteria played a role in the disease process itself.

As to the second possibility—that this was a case of paracolon osteomyelitis with multiple lesions simulating Letterer-Siwe disease—this would not be challenged, except for one consideration. Unquestionably osteomyelitis was present, if we may judge from all criteria, including the clinical course, roentgenographic changes, and microscopic findings indicative of an inflammatory disease which was associated with a definite organism in the bone lesions. That the clinical, roentgenographic, and microscopic findings so closely simulated Letterer-Siwe disease is well founded. However, "simulates" implies that there is another disease entity with similar clinical and histological manifestations in which the etiological factor is something other than an infectious agent. There has been no evidence in the literature to support the assumption that Letterer-Siwe disease is anything other than an inflammatory process. The fact that organisms have not been previously demonstrated in the small number of cases of Letterer-Siwe disease reported is understandable, since the large majority of reports do not mention studies to isolate causative organisms. Thus, the second possibility as to the role of the bacteria is not chosen, since it would necessitate acceptance of the concept, for which there is no sound basis, that there is a similar disease entity not infectious in origin.

An infectious agent has long been suspected as the etiological factor in Letterer-Siwe disease, since the clinical and microscopic findings have represented an inflammatory response of the body. Jaffe and Lichtenstein noted that: "Eosinophilic granuloma of bone, Letterer-Siwe disease and Schüller-Christian disease may be considered as different clinicoanatomic expressions of the same basic disorder. This disorder apparently represents a peculiar inflammatory reaction to some as yet unknown agent of infection. . . ."

It is therefore felt that this case represents Letterer-Siwe disease and that a causative agent was isolated. The paracolon bacilli which were isolated are known to produce disease in man and were shown to be sensitive to antibiotics in the laboratory. Also, the disease process, which was clinically that of Letterer-Siwe disease, was rapidly reversed with antibiotics and, after therapy had been instituted, blood or bone cultures no longer yielded the organism. Furthermore, this infant still had antibodies against his own organism six months after recovery had begun. It also seems apparent that, when there is involvement of bone in Letterer-Siwe disease, this represents an unusual type of histiocytic granulomatous osteomyelitis. This involvement presents a syndrome substantially different from that of ordinary osteomyelitis in that there is generalized lymphadenopathy, hepatosplenomegaly, and a hematological pattern quite unlike that usually seen. The two factors most likely to account for this peculiar response are the relatively immature cellular tissues of the bones and reticulo-endothelial systems of infants and children (to which age group Letterer-Siwe disease is limited, with few exceptions) and the somewhat unusual low-grade inflammatory organisms which set up this reaction. Support for this viewpoint is noted in a case [6] of multiple osteomyelitis of long bones and ribs in which Salmonella paratyphoid B was cultured. Roentgenographically, the lesions in that case were identical with the ones in the case presented. The patient had hepatomegaly and splenomegaly in addition to enlarged nodes. Skin lesions of "herpes Zoster" appeared over the chest. Unfortunately, histological studies were not done and permission for necropsy was not secured. Clinically, this case of multiple Salmonella osteomyelitis represents more than is usually associated with osteomyelitis and has similarity to cases of Letterer-Siwe disease.

The histiocytic granulomatous reaction of bone seen in Letterer-Siwe disease might become as well known as the caseation and tubercle formation in tuberculosis. The analogy may be broadened to include the possibility that several low-grade organisms might be able to cause this histiocytic granulomatous response, as different organisms are capable of provoking a typical tubercle response, especially some mycotic organisms.

REACTIVE HISTIOCYTOSES

Since there has been general agreement in the past decade by the majority of investigators that Letterer-Siwe disease, Hand-Schüller-Christian disease, and eosinophilic granuloma represent different clinical manifestations of the same basic disorder, it seems appropriate to elaborate briefly on these syndromes as to their evolution and the concept of one disease.

Letterer-Siwe Disease

Abt and Denenholz in 1936 proposed that the name Letterer-Siwe disease be applied to "splenohepatomegaly associated with widespread hyperplasia of non-lipid storing macrophages". Credit was given by these authors to Letterer and Siwe who had published reports of cases in 1924 and 1933, respectively. This syndrome is commonly held to be a disease of infancy or early childhood of short duration and invariably fatal outcome. Commonly found are: generalized lymphadenopathy; splenomegaly; hepatomegaly; cutaneous involvement, which might vary from a severe pustular dermatitis to purpura; a rather severe secondary anaemia; and, occasionally, single or multiple lesions of bone. The histological picture is usually that of a widespread inflammation with a striking hyperplasia of macrophages or histiocytes (reticulo-endotheliosis or non-lipid histiocytosis) involving the skin, lymphoid tissue, spleen, liver, and bone. Many of the cases are recorded as having secondary bacterial infections such as otitis media, mastoiditis, and sometimes a severe necrotizing angina.

The disease is not familial or hereditary. Approximately thirty cases had been reported up to 1950, according to Havard, and eleven cases [2,5,7,9,27,29,30,32,36] have been noted since then.

Hand-Schüller-Christian Disease

Hand-Schüller-Christian disease was the first of the triad which was reported in the literature. In 1893, 1915, and 1920, Hand, Schüller, and Christian, respectively, described similar cases which showed the three classical findings of calvarial lesions, exophthalmos, and diabetes insipidus.

In the late 1920's and the early 1930's the importance of the histological picture of the foam cell (lipid granulomatosis, xanthomatosis) was noted. At this time the disease was associated with other primary lipoidoses, namely, Gaucher's, Niemann-Pick, and Tay-Sachs diseases, and some writers believed that the disorder was secondary to hypercholesteraemia. (The latter concept has been disproved.)

More recently it has become apparent that this disease may be present with or without any of the three classic clinical stigmata, depending on which regions in the base of the skull are involved, if any. This condition may occur in children and adults presenting primarily bone lesions, with visceral and cutaneous involvement frequently being present, but not as marked as in Letterer-Siwe disease. The tissues characteristically have so-called foam cells (lipogranulomatosis or lipid histiocytosis). This condition proves fatal in a reported 30 per cent. of cases.[34] It is recognized that occasionally a case of Letterer-Siwe disease, if the patient survives beyond three to four months, will show a histological change from the non-lipid histiocyte into the lipid histiocyte. It is interesting to recall that the second and third biopsies of the case presented showed cells of the type expected in Hand-Schüller-Christian disease.

Eosinophilic Granuloma

In 1940 there were two separate papers describing this entity. Lichtenstein and Jaffe proposed the term "eosinophilic granuloma" and suggested that a virus might be the etiological agent. Otani and Ehrlich also wrote of this condition and designated it as "solitary granuloma". They suggested that trauma might be a possible etiological factor.

Jaffe and Lichtenstein used this term for those cases with bone lesions (usually not in the skull) in which there is no systemic involvement. The lesions are usually single but may be multiple. They proposed that this form of the disease, although related to Letterer-Siwe disease and Hand-Schüller-Christian disease, represented the benign form in which the bone lesions heal readily after simple curettage even without supplementary radiation. They noted that healing may occur by resolution without any therapeutic intervention. The basic component of the granulation tissue from the microscopic standpoint is the histiocyte with an admixture of large numbers of eosinophilic cells. They observed that microscopically this lesion was at times indistinguishable from Letterer-Siwe disease.

The term "eosinophilic granuloma" immediately became popular and many cases have been reported. There has been the tendency in the literature to report cases in which the manifestations surpass the limits proposed by Jaffe and Lichtenstein. Some of the cases recorded as eosinophilic granuloma are cases representing the eosinophilic stage of Letterer-Siwe disease or Hand-Schüller-Christian disease. Cases have even been reported in which there were visceral manifestations. As a result of this trend, lesions containing eosinophils such as Hodgkin's disease of bone, brucellosis involving bone, parasitic infections, occasionally reactive margins of otherwise classical osteomyelitis, and other unrelated specific diseases showing tissue eosinophilia are being lumped together under the heading of "eosinophilic granuloma" to confuse the original concept [25].

It is possible that a case with a single lesion of the skeleton which answers all the clinical and microscopic criteria for eosinophilic granuloma might later exhibit visceral manifestations of the more classical Letterer-Siwe disease, followed by death. Nixon and Perry presented a three-month-old infant with a lesion of the scapula first diagnosed as eosinophilic granuloma. However, later this patient presented visceral manifestations of Letterer-Siwe disease and died. A similar case in a seven-month-old girl was recorded by MacKelvie and Park. This poses the question whether the diagnosis of eosinophilic granuloma should always be associated with as good a prognosis as has been the custom. This is particularly true in infants and children in whom a single lesion presenting characteristics of eosinophilic granuloma may not necessarily be benign, but on the contrary may be the earliest manifestation of Letterer-Siwe disease.

CONCEPTS OF ONE DISEASE

Wallgren, Mallory, Gross and Jacox, Green and Farber, Jaffe and Lichtenstein, Imler, Freud and Grossman, and other investigators have generally agreed that Letterer-Siwe disease, Hand-Schüller-Christian disease, and eosinophilic granuloma represent different clinical manifestations of the same basic disorder.

It becomes obvious through the numerous case reports that there can be overlapping manifestations in this group of diseases which may involve the lymphatic system, spleen, liver, lung, and bones (either solitary or multiple), thus making classification difficult. A case has been reported [36] in which the patient showed a clinical course typical of Letterer-Siwe disease, and microscopically showed an admixture of lipid-containing cells in the thymus and lung tissues. Other tissues showed numerous typical non-lipid histiocytes. There has also been a case [37] in which a lesion in the femur showed collections of sheetlike eosinophils which were characteristic of eosinophilic granuloma. However, in other fields,

typical lipid granulomatous areas were present. This case was diagnosed as Hand-Schüller-Christian disease, because of clinical manifestations of diabetes insipidus.

Curtis and Cawley's first case in 1947 was that of an eight-month-old patient who presented extensive cutaneous lesions including a bone defect noted on roentgenograms of the skull and a few small palpable lymph nodes. The bone lesions healed with x-ray treatment. The patient had a scaly eruption of the scalp similar to seborrheic dermatitis, and histological examination of these pustular cutaneous lesions showed many histiocytes with varying numbers of interspersed eosinophils compatible with "eosinophilic granuloma of bone or Letterer-Siwe disease manifesting cutaneous lesions".

Dundon and Williams presented a seventeen-year-old white female with moderate lymphadenopathy in addition to an osteolytic lesion of the gladiolus. Biopsy of a lymph node showed numerous eosinophils. There was a recurrence of the mass along the sternum with loss of weight, and roentgenograms showed a large mediastinal mass. Another lesion of the gladiolus developed. A second biopsy of a lymph node showed necrosis, neutrophils, eosinophils, and large macrophages. The diagnosis of eosinophilic granuloma was made.

In 1941 Farber stated that he could find no difference between the pathological picture of eosinophilic granuloma and that of Hand-Schüller-Christian and Letterer-Siwe disease. He concluded that eosinophilic granuloma is neither a new nor a separate disease entity.

Engelbreth-Holm, Teilum, and Christensen in 1944 presented patients who originally had solitary granulomatous lesions, but in whom the lesions progressed. Evidence was presented to show that there was a gradual transition in these cases from "eosinophilic granuloma of bone" to the Schüller-Christian syndrome. The authors concluded that the concept of eosinophilic granuloma could no longer be maintained as a nosological entity, but must be considered a clinical and non-symptomatic form of Schüller-Christian disease which often heals without becoming generalized. They noted that the histological appearance of slides in eosinophilic granuloma and that of slides in Schüller-Christian disease showed complete similarity.

From such experiences the concept has been developed that the three entities represent different stages of the same process, as follows:

Stage 1: The proliferative phase with non-lipid histiocytes and eosinophils.

Stage 2: The granulomatous phase, with increase in blood vessels, fibrils, reticulum cells, eosinophils, giant cells, and incipient lipid phagocytosis.

Stage 3: The xanthomatous phase, with numerous foam cells.

Stage 4: The fibrous or healing phase.

It is interesting to note that the stages postulated correspond to the patterns in the case presented, as was shown by serial biopsies. Another point of interest is that two competent pathologists, in reviewing the slides of the second biopsy, in which the eosinophils were prominent, suggested the diagnosis of eosinophilic granuloma.

The close interrelationship of the histological picture in these disorders and the difficulty at times of assigning them to a proper clinical category because of overlapping patterns are apparent. Thus it is believed that the considerable clinical variations depend upon the reactive capabilities of the patient in regard to age, kinds of organs or structures involved, and the extent of the involvement of each organ rather than upon any fundamentally different disease processes.

PARACOLON OF THE ARIZONA GROUP

The study of the organism associated with this case has likewise been most interesting. This group of organisms is a relatively recent discovery. Edwards, West, and Bruner noted that representatives of the group had been first described by Cardwell and Ryerson in 1939 as one of the Salmonella species and that Kauffmann had studied cultures of these organisms in 1941 and designated them as *Salmonella Arizona*. It was found that

the group is closely related serologically to Salmonella, some strains having complete Salmonella O antigens as well as H antigens, which are similar to the antigens of certain Salmonella strains. However, it was recognized that the new group ferments lactose and liquefies gelatin; these properties are not characteristic of the Salmonella group. In 1945 Kauffmann agreed with Edwards [11] that this organism should be withdrawn from the Salmonella schema and classified as a part of the large group of paracolon bacteria which have been called Arizona paracolon bacteria.

Edwards and his associates presented a comprehensive review of the group, noting that the organisms were capable of starting rapidly spreading fatal infections among warm-blooded and cold-blooded animals, especially fowls. At this time, in 1947, there were only four cases in which the organisms had been isolated from human beings. Two were from fatal illnesses in adults and two were from cases of colitis in infants [13]. It was pointed out that it is quite possible that the occurrence of this group has been overlooked in man, since paracolon cultures are habitually discarded without serological examination. In this paper, a satisfactory serological classification was established, which has opened the way for more precise studies to determine the pathogenicity of the organisms. Edwards [12] stated: "In my mind there is absolutely no question that the Arizona paracolon bacteria are pathogenic for man. The infections occur rather rarely, but the persons affected seem to be somewhat more ill than is the case in the average Salmonella infection." He also mentioned that up to 1952 he had obtained a total of twenty cultures from humans.

Due to the fact that cross agglutinations of the paracolon group occur with the Salmonella group, the question is raised as to the possibility of this organism having been mistaken for a Salmonella organism in the past. Although the Arizona paracolon bacterium has not been previously associated with osteomyelitis, Salmonella organisms have been associated with this condition. In a review of cases of Salmonella osteomyelitis, Jetter's report of a ten-year-old girl with a rarefied lesion of the tibia is particularly interesting. A culture of the lesion grew Salmonella paratyphoid B. The patient was anaemic with a low white-blood-cell count. On the fifteenth day the patient presented a palpable liver, followed by purpuric spots and splenomegaly. Otitis developed on the twenty-fifth day, with a temperature of 105 degrees. Further roentgenograms showed multiple lesions of bone, including the proximal third of the shaft of both the right and the left tibia and fibula, scattered lesions in both humeri, in the right pubic bone and ischium, and in the right ulna and radius. There were also suspicious areas in both femora. The patient died on the thirty-ninth day after admission; at that time the purpura had become generalized. It was noted that the patient had had bowel symptoms five weeks prior to admission. The record of the postmortem microscopic examination noted that "Sections of the lesions of the bone showed inflammatory granulation tissue in the medullary and haversian canals. The predominating type of cell was mononuclear. Scattered here and there were large foci of hemorrhage, while in other areas there were smaller patches of granular débris in which some necrotic polymorphonuclear leukocytes were seen." The periosteum was infiltrated with many "mononuclear" cells. Massive infiltration of the lymph nodes, liver, and kidneys by "mononuclear" cells was also recorded. Roentgenograms showed "destructive and productive" bone lesions which were compatible with those in the case presented, although not so much reactive new-bone formation was noted as in the author's case. This might be explained by the termination of the disease by death at a comparatively early stage.

THERAPY

The lack of response to streptomycin therapy was somewhat disturbing to our concept that these lesions are due to the paracolon organisms. The quantitative sensitivity tests by the medicated-disc method had indicated that the organisms were most

sensitive to streptomycin, with chloromycetin second and terramycin third; penicillin had been noted to be ineffective. However, a recent unpublished critical study in the laboratories of the Medical College of Virginia of the medicated-disc method indicates that the test is not accurate for quantitative studies. It is also possible that the lack of response may have been related to the rapidity with which gram-negative rods may develop resistance to streptomycin. Beeson noted, "All species of bacteria can become highly resistant to streptomycin, often rapidly, not only *in vitro* but *in vivo*. Since streptomycin resistance is permanent, a time may be visualized when most of the sensitive bacteria will have acquired resistance."

In any event, we feel that the clinical trial with streptomycin proved that it was not the drug of choice, while the rapid and complete response to chloromycetin and terramycin with disappearance of the organisms from the blood stream and bone lesions clearly established the effectiveness of these agents.

It has been noted in the recent literature that three other cases of Letterer-Siwe disease have responded to antibiotics. Aronson in 1951 reported a case diagnosed as Letterer-Siwe disease in an eighteen-month-old child; this patient responded to streptomycin. Bierman and his associates in 1952 reported on twins, nine months of age, who had an onset of febrile illness within a few hours of each other, followed by skin eruption, multiple bone lesions, lymphadenopathy, splenomegaly, and hepatomegaly. Biopsies showed a non-lipid histiocytosis in lymph nodes from each patient, and the diagnosis of Letterer-Siwe disease was made. One of the patients was given aureomycin for a short course, to which he responded. This twin was placed on antibiotics, including penicillin, aureomycin, and chloromycetin, while the other was given roentgen therapy. It was noted that there was a response in the patient treated with antibiotics, whereas the one receiving roentgen therapy showed only temporary improvement, which was followed by further progression of the disease. The second twin was then placed on antibiotics, with recovery, and both were perfectly well when last seen, four years after the onset.

Bierman has informed the author that there has been another unreported case of Letterer-Siwe disease, in Minnesota, which has responded to antibiotics. These four additional patients who have responded to antibiotics provide further evidence that the etiology of Letterer-Siwe disease is an infectious organism or organisms sensitive to the antibiotics used.

This success in therapy contradicts the general opinion expressed in the literature that Letterer-Siwe disease is invariably fatal, no therapy being of value. This point should be emphasized, as the patient presented just missed being a victim of the prevalent concepts which discourage therapy.

All three of the patients in the literature had periods of therapy with penicillin, which was noted to be ineffective. MacKelvie and Park presented a case which also did not respond to penicillin. Possibly the organisms in these four cases were similar to the penicillin-resistant Arizona paracolon bacterium.

It is of some value to ascertain whether the antibiotics or roentgen therapy was the effective agent or whether there was a synergistic effect. Dr. Merrill C. Sosman reviewed the case history and stated, "I would assume that the good response was due to the combined antibiotic therapy rather than x-ray treatment". He added that he noted very little beneficial response to irradiation in Letterer-Siwe disease. "In general, eosinophilic granuloma and Hand-Schüller-Christian disease respond well to small doses of 200 to 300 r to the local lesions, but they may recur in the area treated or new lesions may spring up elsewhere."

This patient had no therapy directed to a single lesion, but received in spray form the minimum amount known to be necessary to affect a single lesion when given locally. Therefore, it is not believed that the roentgen therapy significantly influenced the patient's course.

SUMMARY

The case presented has shown a progressive, near-fatal illness with clinical, roentgenographic, and microscopic signs which support the diagnosis of Letterer-Siwe disease, the etiology of which has been postulated to be infectious.

All features of the disease process receded immediately following antibiotic therapy and no organisms could be isolated in repeated cultures following the remission. In consideration of these facts, it is believed that the case is one of Letterer-Siwe disease, in which the causative agent was isolated and healing was accomplished with antibiotic therapy.

The final proof of this interpretation will, of course, depend upon the isolation of similar or different organisms from other cases. The paracolon group are commonly discarded in the laboratory as of no significance. Thus, organisms which have been regarded as not significant or contaminants may be responsible for other cases. Only the accumulation of a considerable body of cases studied intensively will eventually prove whether or not any organisms recovered are opportunists, contaminants, or causative agents, or whether organisms can be recovered with any degree of frequency.

CONCLUSIONS

1. It is felt that sufficient evidence has been presented to discard the popular concept that Letterer-Siwe disease is necessarily fatal and that the course cannot be changed by therapy.

2. This case strongly supports the concept of an inflammatory basis of this group of diseases, the etiological agent in this particular case being the paracolon bacterium of the Arizona group.

3. This case also supports, through serial biopsies, the concept that Letterer-Siwe and Hand-Schüller-Christian disease are one disease, each representing a different histological phase.

4. In searching for low-grade inflammatory organisms in similar cases, multiple biopsies are indicated, with adequate cultures of blood and biopsied tissue.

5. Even in the absence of a bacterial culture in a similar case, combined antibiotic treatment is indicated. The antibiotics of choice are probably chloromycetin and terramycin. Since the clinical course did not change in any of the four patients with Letterer-Siwe disease treated with penicillin, it is felt that this is probably the least effective antibiotic for organisms likely to cause the condition.

6. The three diseases are a group of infectious processes with varying clinical manifestations, depending upon which organs or structures are involved, the age of the patient, and the extent of involvement.

7. Care should be taken in giving a prognosis in infants and children who have a lesion with the criteria of "eosinophilic granuloma", since multiple lesions and different patterns may subsequently develop.

8. The criteria proposed by Jaffe and Lichtenstein in regard to the use of the term "eosinophilic granuloma" should be emphasized; the tendency to record any case with eosinophilia as a case of eosinophilic granuloma should be avoided.

NOTE: The author wishes to acknowledge his gratitude to Dr. Lent C. Johnson of the Armed Forces Institute of Pathology, Washington, D. C., whose surprising prediction that "an unusual strain of Salmonella" might be the etiological factor in this case resulted in the finding of the organism and application of effective therapy. His suggestions for the progressive study of the case and its interpretation have been invaluable.

The author also wishes to express his gratitude to the following:

To Dr. Gordon C. Hennigar, pathologist at the Medical College of Virginia, Richmond, Virginia, for his enthusiasm in the study of the case and for preparation and interpretation of microscopic data. He will publish in detail the pathological findings connected with the multiple serial biopsies.

To Dr. Henry L. Jaffe, Hospital for Joint Diseases, New York City, and Dr. Merill C. Sosman, Peter Bent Brigham Hospital, Boston, Massachusetts, who kindly reviewed the case and offered their respective expert opinions, which have added considerably to the value of the case.

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DISCUSSION

Cystic Angiomatosis of the Skeletal System

(*Continued from page 420*)

typically angiomatosis of the cavernous type, one of the cases showing a great deal more bone formation than the other.

The background of this condition has been well presented. We do not know too much about these lesions; we do not see very many of them. I also feel that they are probably hamartomata, a developmental anomaly rather than a true neoplasm which tends to grow wildly locally, or to metastasize. None of the sections showed mitotic figures or other evidences of malignancy.

In their conclusions the authors state that a small unidentified angioma may be the primary etiological factor in simple bone cysts, as we currently use the term. We cannot accept this theory, on the basis of our experience with hundreds of simple bone cysts, many of which we section in their entirety. We do see tissue of the angiomatous type in the walls or lining membranes of some of these cysts — some of the simple cysts. We also see zones of giant-cell tissue, but we cannot call these lesions giant-cell tumors when they are basically cystic. We have seen several simple bone cysts which have the gross and the roentgenographic appearance of some of the lesions demonstrated. We often see a thin shell over the cyst, bluish in color, and I have seen pulsation of the fluid which would suggest a relation to vascular tissue inside the cyst. This might even be a major or causative relationship, but I have yet to see sections of angiomatous tissue from one of these cysts which I would consider to be etiologically conclusive.

I think this is a very interesting syndrome, but I must make one definite comment — let us not call it by any proper name. For the condition presented, we can use the term "cystic angiomatosis".

Dr. Kimmelstiel (closing): I would like to thank both of the discussors for their kind remarks. I am happy to know that Dr. Compere agreed with our concept of cystic angiomatosis. He was correct in refusing to accept the idea that all simple cysts are due to small hidden angiomata. I did not mean to convey that impression. I meant to say that some of them may be a result of angiomata.

SARCOID DISEASE OF BONE AT THE ANKLE JOINT

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From the Department of Orthopedic Surgery, Mount Sinai Hospital, Chicago

Sarcoid involvement of a joint is unusual and the recording of such a case is deemed worth while. The pitfalls which befell the author in the diagnosis and treatment are herewith presented.

The patient, a well developed, muscular white male of fifty-two, stated that he had injured his right ankle when he stepped on a stone about seven months before examination. He had experienced immediate pain in the ankle, followed by swelling the next day. X-rays were made and a cast was applied. This was removed three months later, but was re-applied after a month because of persistence of pain. The ankle was swollen, blue, cold, and tender at that time. Six weeks later the cast was removed, but the pain and swelling remained unimproved. The roentgenograms made at intervals during this period of treatment revealed an arthritic spur on the anterior lip of the tibia and diffuse osteoporosis of the ankle and of all the bones of the foot. This latter finding had appeared only in the films taken after immobilization.

The previous history indicated that the patient had been treated for a swollen ankle three years previously. His occupation was that of construction worker and he traveled to various parts of the country, especially Texas and the San Joaquin valley of California.

The pain occurred at intervals even when he was recumbent, but was aggravated and severe when he was bearing weight. It was located diffusely about the ankle. Any form of external heat increased the symptoms. The motion in the ankle had become restricted since the onset of pain.

Examination on March 5, 1951, revealed moderate soft-tissue swelling, which was non-pitting, about the ankle, slight tenderness over the anterior joint interval, and slight crepitation palpable with ankle motion. Dorsiflexion and plantar flexion were limited 10 to 15 degrees, but subtalar motion was normal. The dorsalis pedis and posterior tibial pulsations were palpable. The patient walked with a marked limp, with the foot held in slight plantar flexion.

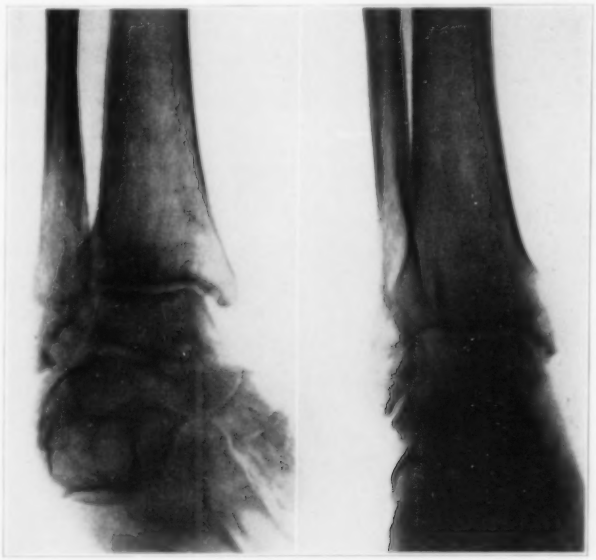

FIG. 1

Oblique and anteroposterior roentgenograms of ankle made March 5, 1951. Note the cystic areas in the medial malleolus, one of which seems to be directly invading the joint space. (From the Department of Pathology, Mount Sinai Hospital, Chicago, Illinois.)

The patient was admitted to the Hospital on the same day for study. X-rays at that time revealed spotty atrophy of all the bones about the ankle and tarsal region; cystic changes were most marked about the tibiofibular interval and on the joint aspect of the medial malleolus (Fig. 1). These clear circular lesions showed very little reactive bone and appeared to penetrate the joint. The joint space was of normal width as compared with the opposite joint. The bone trabeculae distal and proximal to the joint were diffusely thinned. A small cauliflower-like bony outgrowth from the posterior aspect of the talus was also noted in the opposite talus. Chest roentgenograms and the Mantoux test were negative.

Laboratory findings showed: serum calcium, 8.5 milligrams per 100 cubic centimeters; phosphorus, 3.7 milligrams per 100 cubic centimeters; uric acid, 3.4 milligrams per 100 cubic centimeters; and alkaline phosphatase, 3.4 King Armstrong units.

FIG. 2

Photomicrograph (× 250) demonstrating epithelioid accumulations, sparseness of lymphocytes, capillary loops of granulation tissue, and fibrocartilage at right edge of section. Note absence of giant cells and macrophages. (From the Department of Pathology, Mount Sinai Hospital, Chicago, Illinois.)

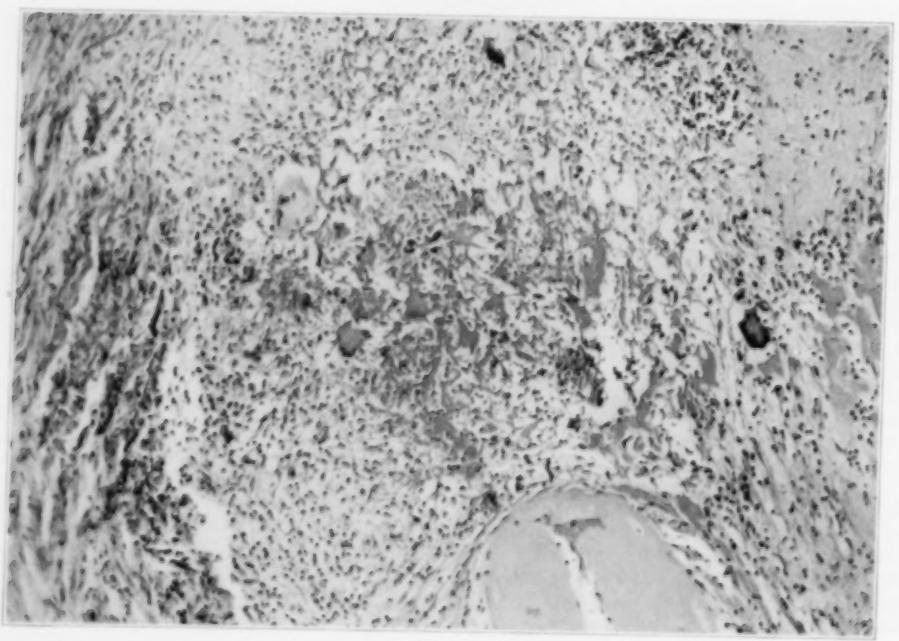

FIG. 3

Photomicrograph (× 250) showing rare giant cells, typical densely staining material in the one at the top, and peculiar small accumulations of colloid material; lymphocytes are sparse and diffusely distributed. (From the Department of Pathology, Mount Sinai Hospital, Chicago, Illinois.)

Red blood count, 4,700,000
Hemoglobin 13 grams
White blood count, 14,000
Neutrophils 67 per cent.
Eosinophils 3 per cent.
Lymphocytes 28 per cent.
Monocytes 2 per cent.

Urinalysis and serology were negative. A trial administration of colchicine gave no relief.

Operation was performed on March 12, 1951; the ankle was exposed through an anterior longitudinal incision. A small pea-sized synovial protrusion through the anterior capsule was encountered. The synovial membrane was thickened and fibrotic. The cartilage over the tibia was thinned, fibrillated, dull, yellow in color, and fibrotic in texture. In marked contrast, the cartilage over the talus was only slightly dull and otherwise presented a normal appearance; the underlying cancellous bone was bright red, soft, and bled readily. The cartilage over the inner aspect of the medial malleolus was not dissimilar to that on the rest of the tibial surface. Upon its removal, no cystic areas or tissue grossly different from the tibial cancellous bone exposed elsewhere was found. A portion of this malleolar cartilage and bone was removed for microscopic study. Arthrodesis was performed by sliding of an intramedullary tibial cortical graft obtained from well above the involved area. Convalescence was rapid; gradual weight-bearing was allowed at eight weeks, and the patient returned to full activity in five months.

FIG. 4

Lateral and anteroposterior roentgenograms of ankle, made August 20, 1951, five months after operation. Cystic areas are still visible but seem less obvious. Fusion appears to be taking place, with incorporation of the intramedullary graft.

Microscopic sections revealed granulation tissue with accumulations of epithelioid cells in clusters (Fig. 2). No evidence of caseation necrosis could be found, only very occasional small areas of colloid-like deposits (Fig. 3). Giant cells resembling the Langhans type were infrequent and were found only in a few sections. One such cell (Fig. 3) contained the densely stained material characteristic of sarcoidosis. There was a notable lack of the dense aggregations of lymphocytes or monocytes such as one invariably finds in tuberculosis. The cluster of epithelioid cells in Figure 2 bordered on an area of cartilage which was fibrous in type, gradually merging with the normal hyaline cartilage below. One cannot determine from these sections whether the sarcoid lesion was invading the cartilage or whether the cartilage was undergoing fibrous transformation without being invaded. No region of interruption in continuity of the cartilage could be found. Bone trabeculae were sparse, thinned, and for the most part were replaced by granulation and mature fibrous tissue. Sections of the joint capsule and synovial membrane revealed increase in the fibrous-tissue elements and an occasional well localized "hard tubercle". Lymphocytes were very scarce and giant cells could not be found at all. Acid-fast stain for bacilli and guinea-pig inoculation of suspected material were negative.

The patient was last seen on August 20, 1951, five months after surgery. At that time he stated that his activity was unrestricted and included riding a bicycle. The foot was of normal color, size, and warmth; a barely perceptible limp was present. Roentgenograms (Fig. 4) revealed excellent development of the fusion. The sliding intramedullary graft was visible only by its cortex, which was thinner than on previous films, indicating that the normal process of creeping substitution was taking place. No indication of invasion of the graft by the pathological process could be found. The cystic areas were still visible in a few regions, but in general seemed to be less obvious, although this may have been due to variation in roentgenographic technique. The talus was not involved.

The man was allowed to return to work, restrictions being placed on his climbing scaffolds and walking

on rough terrain. His occupation involved working on large construction jobs in various parts of the country, and his transfer to distant regions probably accounts for his failure to return for follow-up examination. The representative of the insurance company in the district where he was last known to have worked informed us that the patient was engaged in his previous occupation, which involved scaling ladders.

COMMENT

This is an unusual location for sarcoidosis of bone. The disease shows a definite predilection for the short bones of the hands and feet, with less frequent involvement of the carpus, tarsus, long bones, and vertebrae.

Two forms of the disease are recognized. The circumscribed type is characterized by cystic areas of rarefaction in the medullary canal, with little or no reactive sclerosis. The diffuse form produces a fine reticulated pattern involving large portions of the bone and is usually associated with broadening of the shaft and thinning of the cortex. (The cortex is thinned and elevated but rarely penetrated.) Schaumann has shown that lesions may not be demonstrable by x-ray.

The clinical course is quite prolonged, but is usually benign. Diagnosis may be difficult. Sarcoidosis should be kept in mind in any low-grade process such as was presented by this case. Although final diagnosis depends on biopsy and stains negative for acid-fast bacilli, presumptive evidence of the disease clinically may be found in the presence of skin lesions, lymphadenopathy, uveoparotitis, iridocyclitis, x-ray evidence of hilar adenopathy, and the typical cystic areas of destruction in the phalanges seen in the roentgenogram.

For detailed descriptions of this disease, the articles by Curtis, Freiman, Jüngling, and Sweet are excellent.

The findings in this case would seem to indicate that the disease process does not involve the articular cartilage. This should help in differentiating it from tuberculosis. The joint changes seen here appeared to be degenerative in origin, similar to those seen in mechanical derangements. Arthrodesis in a weight-bearing joint such as the ankle would seem to be the only way of relieving pain satisfactorily.

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SYNOVIAL SARCOMA OF THE FOOT

A Case Report

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Synovial sarcoma is a malignant mesenchymal tumor composed of spindle-cell and special synovial tissue. The origin of these cells is not clear. Haagensen and Stout hold it "questionable whether or not they are derived from the normal lining cells of joints, tendon sheaths, and bursae, because the tumors are usually outside of these structures, although often in close proximity to them". King described four main histological forms of the synovial-tissue component characterized by (1) mucin formation, (2) synovial spaces, (3) endothelial and "gland" spaces, and (4) epithelium-like tissue. He favored the theory that, with appropriate stimulus, the connective tissue anywhere is capable of this kind of differentiation.

The tumor is uncommon. Pack and Ariel in an eighteen-year period gathered the histories of 717 patients with malignant neoplasms of the somatic tissues; out of these they found only sixty cases of synovial sarcoma, comprising 8.4 per cent. of all malignant neoplasms of the soft somatic tissues in their series. However, the true incidence is not known, for not all cases are recognized; or, if they are recognized, not all are reported. It was suggested by Bowman that "all cases should be reported in order that sufficient clinical experience and information can be promulgated to further the patient's chance of survival".

There follows the case history of a patient who was treated by surgery and later with nitrogen mustard for pulmonary metastases.

The patient was a colored housewife, thirty-two years old, who was first seen in the Rhode Island Hospital in September 1950, complaining of a lump on the dorsal aspect of the left foot. In January 1950, she had first noted a slightly tender area on the dorsal surface of the left foot, which gradually increased in size and which was occasionally painful. The patient sought advice because the lump caused a certain amount of disfigurement and pain and interfered with her footwear.

The impression of the Surgical Service was that the lump was a large ganglion on the left hallux. Just anterior to the "ganglion" there was a callus. No adenopathy was noted.

Hemoglobin was 9.2 grams; red blood count, 3,100,000; white blood count, 9,800. A Wassermann test was negative. Miniature chest films showed no pathological changes.

The patient was hospitalized and local excision of the "ganglion" was performed in September 1950 under nitrous oxide, ether anaesthesia. An incision was made along the medial aspect of the left big toe, curving dorsally over the head of the first metatarsal bone. The mass, measuring approximately two by one inches, was found to surround the extensor tendon of the left great toe and was adjacent to the bursa of the head of the first metatarsal bone. It extended over the dorsum of the first metatarsophalangeal joint. It appeared to have a smooth, glistening surface and was separated from the surrounding connective tissue with some difficulty because of connections with the tendon sheath of the left first and second toes. It extended medially into the connective tissue of the great toe. Near the end of the procedure the "ganglion" gave way and some dark brown bloody fluid exuded from it. The postoperative course was uneventful.

The excised specimen consisted of irregularly shaped bits of fibrofatty tissue and varied in size from one to five centimeters in diameter. Some sections of the fragmentary portions revealed masses of oval and round cells, closely packed together and finely interlaced with strands of spindle cells. These cells were quite uniform, undifferentiated rudimentary types, forming solid masses and gradually disappearing in the fibrous spindle-cell tissue. Other sections showed dense collagenous fibrous tissue and associated groups of spindle cells, which in some places formed interlacing sheets and in other places cords, giving the appearance of a stromal type of growth. The spindle cells appeared moderately plump and showed varying degrees of transformation into polyhedral and spheroidal cells. The spindle-cell tissue tended to be arranged in such a pattern that small, oval, stellate, slitlike, and tubular spaces were formed. There was also a papillary projection seen in a tubular space, but this phenomenon was not generally noted. The spaces were lined with epithelium-like cuboidal cells, which showed fairly good demarcation from the subjacent tissue. In places the cuboidal

cells lined relatively small spaces and were transformed into columnar forms showing much better demarcation and a glandlike appearance. In some places the lining resembled a synovial surface. The cuboidal cells in some areas formed nests, suggesting an abortive attempt to form acini. Generally the nuclei were fairly uniform in size, showing variations which corresponded to changes in cell shape. There was a general, but variable hypochromatism. Mitotic forms were frequently seen in some fields. A few cells contained the brown pigment consistent with old-blood pigment. One observer noted a collection of cells in hyalinized areas suggesting cartilage cells [3]. The tumor tissue was intimately related to the surrounding mature fibrous tissue, and invasion was noted at some points. Because of the spindle-cell stroma, the masses of oval round cells, the lined spaces, clefts, and other cell characteristics, it was concluded that the cells were of synovial-cell origin; therefore, the diagnosis of synovial sarcoma was made. Consultation was obtained from Dr. Granville A. Bennett and Dr. Henry L. Jaffe who concurred in our opinion.

On receipt of the pathologist's report, the patient was recalled for further treatment. She was advised to have a mid-thigh amputation. This procedure was accepted by the patient and her husband. Preoperative examination revealed no palpable lymph nodes. The scar of local excision in the foot was well healed with some deep pigmentation, and the skin was somewhat fixed to deeper structures. A roentgenogram of the chest was negative and a roentgenogram of the left lower extremity showed no signs of any proliferative or destructive disease. Hemoglobin was 9.5 grams; the sedimentation rate (Wintrobe-Landsberg method) was 28 millimeters in an hour.

A Kirk amputation through the lower third of the left femur was performed early in October 1950. The procedure was well tolerated. The postoperative course was entirely satisfactory, and the patient was discharged after fourteen days in the Hospital.

In the operative specimen no lymph nodes were recovered. Dissection of the popliteal space failed to reveal evidence of tumor in the popliteal, tibial, or peroneal veins; no involvement was found in the saphenous vein. The corresponding arteries were also negative for tumor. A section from the region surrounding the scar on the foot revealed a hyperkeratotic surface with a deeply pigmented basal layer; areas without pigmentation were seen as well. Tiny areas of superficial ulceration were seen in one section. The underlying fibrous tissue contained maturing fibroblasts.

The patient was seen in the Tumor Clinic in June 1951, ten months after excision. The groin was not remarkable at that time. She had gained seventeen pounds since the summer of 1950. In July 1951, she had a brief episode of cough and emitted blood-streaked sputum, but she sought no aid. Because of persistent hemoptysis she was re-admitted on September 13, 1951. No adenopathy was noted on physical examination. A roentgenogram made two days later showed a small nodule in the lower portion of the left lung. Bronchoscopy was done; a clear trachea and bronchial tree were seen. Aspiration of fluid showed a greyish secretion with considerable sediment, but no malignant cells or acid-fast organisms were found. The nodule was considered an early metastatic lesion and no palliative surgery was offered, because it was felt doubtful that this was a solitary metastasis. She remained afebrile and was discharged after ten days.

Subsequently, the patient continued to cough up small amounts of blood almost daily and noted pain in the anterior part of the right side of the chest. A roentgenogram made in October 1951 showed rounded nodular infiltration in both lung fields and a nodule in the left hilum measuring 3.5 centimeters. There was also a small pleural effusion on the right. Diffuse metastatic disease of the lungs was evident. X-ray treatment was suggested, but the patient failed to return.

By December 1951, the patient was showing signs of steady deterioration. The hemoptysis persisted and the patient experienced discomfort when lying on her right side. She lost weight quite rapidly and, five days prior to re-admission in December, dyspnoea developed, as well as wheezing, followed by pain in the right shoulder, a feeling of strangulation in her neck, husky voice, and vomiting.

On admission the patient's dyspnoea and cough were only partially relieved by oxygen. She showed evidence of fluid in the right pleural cavity; the metastatic nodules in the left lower lobe and left hilar region showed enlargement; and there was an obvious increase in the size of the left hilar glands.

Blood chemistry studies were not remarkable. The white blood count was 26,570 with 81 per cent. neutrophils; the sedimentation rate (Wintrobe-Landsberg method) was forty-eight millimeters per hour; protein, albumin, and alkaline phosphatase determinations were within normal limits.

She received penicillin. A total of 4,200 cubic centimeters of hemorrhagic fluid was withdrawn by several thoracenteses. Cell blocks from this fluid revealed round cells with large nuclei, which were consistent with tumor cells, and active cells of the pleural lining. Since x-ray therapy was not feasible because of her general debility, treatment with nitrogen mustard was instituted and attempts were made to observe the behavior of the pulmonary metastases. One-tenth milligram per kilogram of body weight was given intravenously for four subsequent days. This therapy resulted in a brief subjective effect only. During the week after the treatment, the patient stated that she felt better, her appetite improved, coughing subsided, and she breathed more easily. The white blood count fell from 30,000 to 3,000 or 4,000 during the second week; it gradually rose with the cessation of nitrogen mustard to 7,900.

On completion of the therapy, an x-ray of the chest showed no change in the left lung; the right lung could not be evaluated because of the pleural thickening and fluid. Her clinical condition after the brief

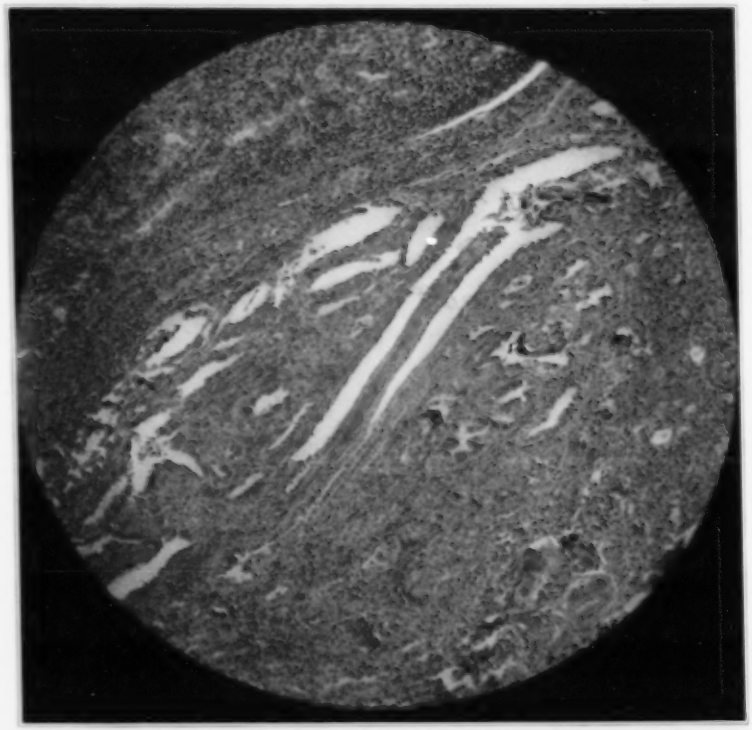

Fig. 1

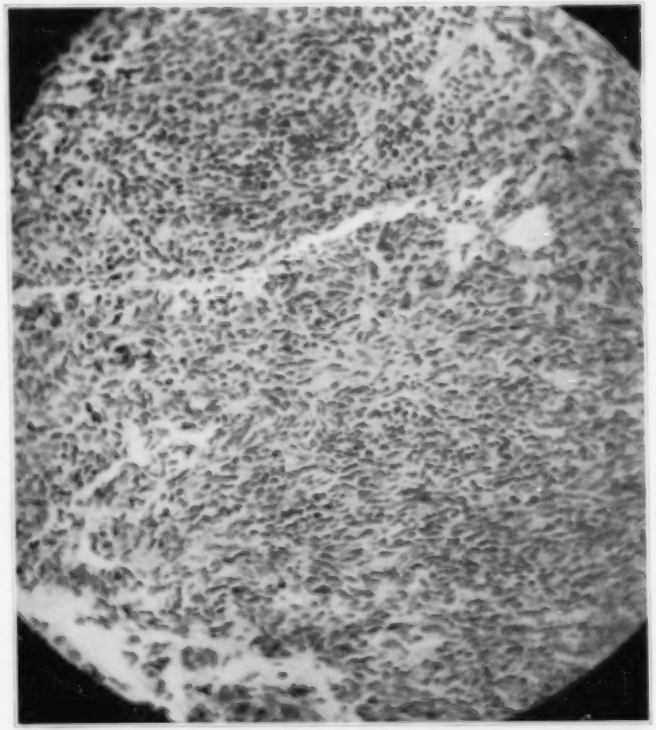

Fig. 2

Fig. 1: In the photomicrograph (× 90) are seen masses of closely packed oval and round cells, spaces and clefts, interlacing strands, and cords of spindle cells which show a papillary projection in a tubular space.

Fig. 2: Photomicrograph (× 200) reveals an area suggesting fibrosarcoma.

FIG. 4

FIG. 3

Fig. 3: Shown in the photomicrograph (× 550) are spaces lined with epithelium-like cuboidal cells and spindle-cell stroma. Note the demarcation.
Fig. 4: Photomicrograph (× 550) shows glandlike spaces lined with columnar and cuboidal cells.

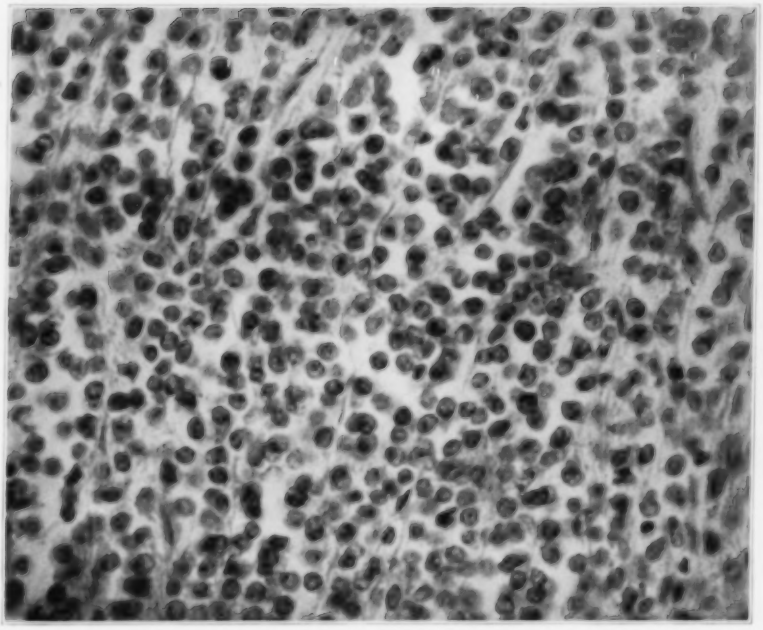

FIG. 6

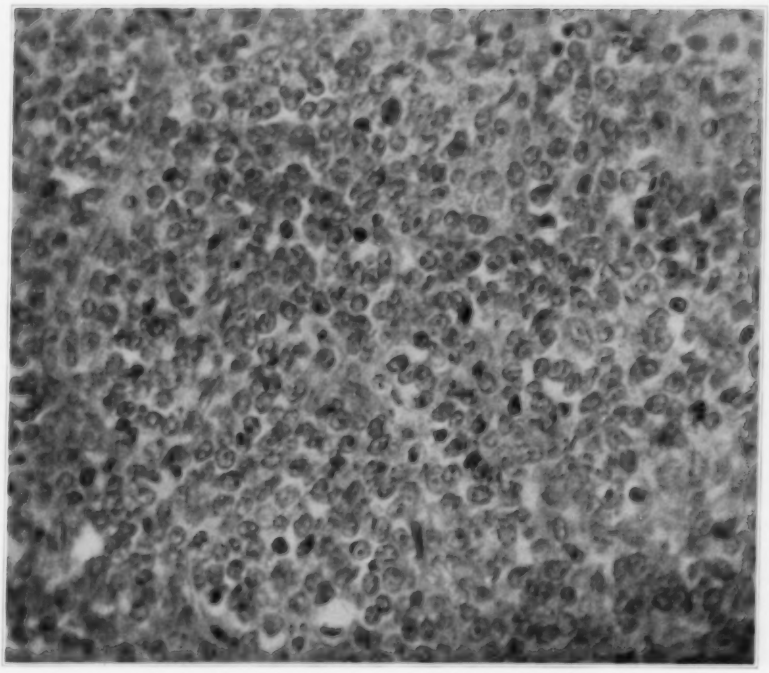

FIG. 5

Fig. 5: Photomicrograph (× 500) showing round and oval cells and strands of spindle cells from the tumor.
Fig. 6: Photomicrograph (× 540); round and oval cells from pleural metastasis are seen.

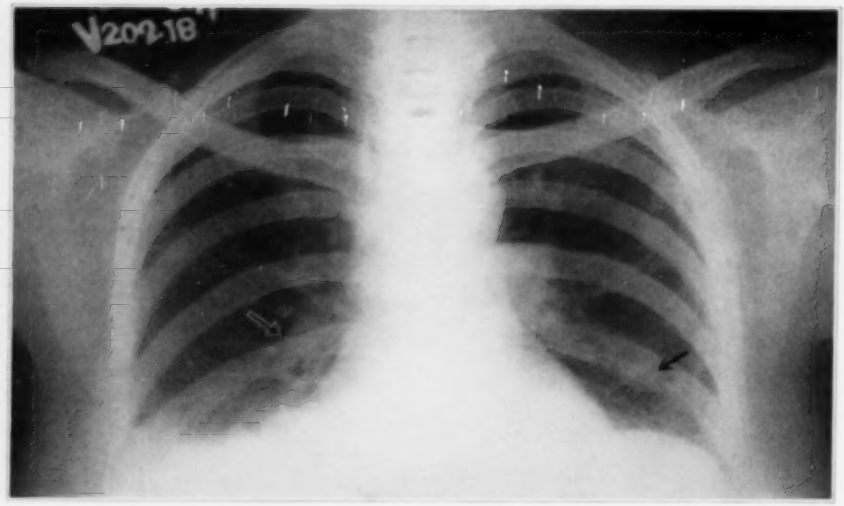

FIG. 7

A roentgenogram of the chest shows the extensive bilateral pulmonary metastases twenty-two months after onset of first symptoms.

interval of subjective improvement was not altered. In the terminal two weeks, she was apathetic and she had occasional spiking fever, cough, nausea, and increasingly severe dyspnoea. She died on January 31, 1952, just two years after the tumor was first noted.

Autopsy Findings

The right pleural cavity showed a massive loculated bloody effusion. The right lung was completely collapsed and buried. The parietal pleura on the right side contained several tumor masses, eight to ten centimeters in size, located in the upper portion of the chest wall anteriorly. The superior pole of the right lung was bound down to the chest wall in the tumor tissue; it was also quite closely bound to the superior mediastinum, pericardium, and the posterior portion of the parietal pleura along the vertebrae. Metastases in lymph nodes along the right main bronchus and the right side of the trachea were noted. These nodes definitely contained tumor tissue and extended up along the mediastinum into the lower portion of the neck to the subclavian artery. While there was no evidence of tumor mass in the right lung parenchyma, the tumor mass had actually encased the right lung and had replaced the visceral pleura. There was a tumor mass in the posterior upper aspect of the left lower lobe, three to four centimeters in diameter. It consisted of yellow-grey necrotic tissue which was macerated and easily shelled out. It was felt that the rest of the spread must have occurred from this mass near the left hilum, for the gross appearance suggested propagation of the tumor from this nodule to the mediastinal nodes and then into the right portion of the chest. There were also three nodules near the pleural surface in the left lung. Extensive bronchopneumonia was present in the left lung. A section of necrotic lesions of the lung showed fibrous tissue and interspaced anaplastic tumor cells. These cells were oval and had hardly any cytoplasm. They resembled the cells seen in malignant lymphoma or endothelioma. There was rarely an attempt at "gland" formation. The lung tissue was not invaded by the tumor cells. The right pleura showed similar tumor formation, and clumps of tumor cells were seen in the vascular tree of the right lung. The lymph nodes from the mediastinum showed similar metastatic tumor. The pelvic organs revealed chronic endocervicitis, hydrosalpinx, and chronic salpingitis; there was also perisplenitis and a healed infarct of the spleen. The bone marrow showed hypo-activity, presumably caused by the treatment with nitrogen mustard.

COMMENT

The course of this patient was similar to that in several cases previously published in the literature. There was some indication of trauma to the foot in this patient, which was due to the obvious pressure of the patient's footwear, especially since the tumor had a hemorrhagic center and her chief complaints were pain and tenderness. The insidious growth and appearance suggested "ganglion" to several observers. The affected skin area

was red and tender at the onset of symptoms, but evidence of previous inflammation could not be ascertained. Before excision malignancy was not suspected. The localization of the synovial sarcoma to the foot is second in frequency (18.3 per cent. in the series of Pack and Ariel). In their series, the patients with a painful tender mass sought medical attention in 7.8 months on the average, which corresponds to the eight months' previous history of our patient.

The tumor presented a subcutaneous nodule adhering to the tendon sheaths and had extensions into the surrounding tissue. Bones, joints, and tendons were apparently not invaded. X-ray examination showed no calcification. Sections showed siderophagic elements, and chondrification was represented by cartilage cells. The tumor metastasized to lungs, mediastinal lymph nodes, and pleura with no evidence of regional gland or bone metastases. We found clumps of tumor cells in the vascular tree of the lungs which suggested the invasion of blood vessels by tumor cells, indicative of the hematogenous spread of this neoplasm. It was likely that the metastases spread from the solitary node in the left lung to the pleura and mediastinal lymph nodes by continuity and lymphatic pathways. The distant metastases to the lungs took place in ten or twelve months after local excision (in ten months as evidenced by hemoptysis; in twelve months as revealed by roentgenogram). The time for metastases after treatment in the series of Pack and Ariel was from three months to five years. After the demonstration of metastases, the patient had a rapid course of four months. The location of the tumor in our patient is significant; it is remarkable that no patient with malignant synovioma of the foot has survived a five-year period in the series reported [6]. The attempt to bring pulmonary metastasis to regression through treatment with nitrogen mustard failed.

This tumor showed the characteristics of two co-existing cell tissues and numerous transformation forms which created the impression that these cells were the result of differentiation of the same multipotential generic cells. Tissue-culture studies of synovial tissue by Murray, Stout, and Pogogeff proved that the cells of these tumors may assume either form. Metastatic cells were of the oval and round rudimentary cell type, indistinguishable from those in other mesothelial tumors.

Generally speaking, it may be said that a neoplasm composed of well differentiated cells is of low-grade malignancy. However, this principle is not applicable to synovial tumors [4]. This was well demonstrated by our patient in whom the tumor showed not only well developed synovial spaces but also solid masses of undifferentiated cells. The course was malignant.

Surgery (excision and amputation) failed to achieve a cure in our patient. Pack and Ariel reported four five-year cures out of ten cases after wide resection and postoperative irradiation. None of eight patients who had had amputation alone survived this period.

No conclusion can be made as to the value of nitrogen mustard in the treatment of metastases.

NOTE: We wish to express our appreciation to Dr. Herbert Fanger, Director, Department of Pathology, Rhode Island Hospital, to Dr. William Cannon for the pathological report and assistance, and to Mr. B. C. Staugaard for the photographic work.

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GIANT-CELL TUMOR OF THE SPINE

A Report of Two Cases

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Tumor statistics demonstrate the predilection of giant-cell tumors and of bone cysts for long bones. Vertebral involvement is rare, as reported by Coley, who found only three giant-cell tumors in the spine among 124 cases, by Geschickter and Copeland, who found two among eighty-two tumors, and by Meyerding, who found no spine involvement in his series of forty cases. The similarity between these two entities makes differential diagnosis difficult. Coley suggested that the term "bone cyst" be reserved for those neoplasms appearing in juxta-articular regions, always on the shaft side of the epiphysis, and before epiphyseal closure; the term "giant-cell tumor" would then describe a lesion which was similar but which occurred after epiphyseal closure. The occasional appearance of giant-cell tumor characteristics before epiphyseal closure prompted Geschickter and Copeland to label this intermediate group as "giant cell variants of the bone cyst".

The presentation of two patients with giant-cell tumor localized in the spine seems justified, as it illustrates a combination of roentgen-ray and surgical treatment.

Case 1. D. D., six years old, was admitted to the Nebraska University Hospital on September 3, 1939, with the complaint of pain in the low back, which was sudden in onset after a fall down a flight of stairs six months before. The pain was aggravated by any direct pressure; there was radiation into the back of the left hip.

Physical examination revealed an obese white girl, with considerable lumbar lordosis. There was a tender,

Fig. 1-A
September 5, 1939

Fig. 1-B
August 10, 1941

non-pulsating swelling in the left low back; spine motion was 75 per cent. of normal. The temperature was 98.8 degrees orally, pulse 88, respiration 26; blood studies showed 4,200,000 red blood cells, 10,800 white blood cells with 57 per cent. lymphocytes. The sedimentation rate (Wintrobe method) was 12 millimeters per hour. The tuberculin and Wassermann tests were negative.

The x-ray examination showed a destructive lesion in the right half of the first sacral vertebra extending into the wing of the ilium; margins of the defect were irregular but fairly sharply defined; the body of the fifth lumbar vertebra tilted into an area of destruction in the first sacral vertebra (Fig. 1-A).

A biopsy under general anaesthesia was done on October 13, 1939, through an incision above the right posterior superior iliac spine. Friable tissue, gritty to the touch, was encountered beneath the sacrospinalis origins. Considerable oozing of blood was easily controlled by pressure; closure was done in layers. Histological study of the specimen revealed dense fibrous tissue with numerous giant cells, containing as many as ninety nuclei, located chiefly in the middle of the cell; some isolated spicules of bone and cartilage were scattered about. The tentative diagnosis was benign giant-cell tumor of the sacrum.

Roentgen therapy consisting of 1200 roentgens was given in six doses from November 12, 1939, to November 20, 1939, through two posterior oblique ports, an attempt being made to shield the ovaries. Immobilization consisted of a body cast extending down to the left knee for three months.

X-ray examination on August 10, 1941, showed improved bone detail in the tumor site; the lesion was arrested. However, a marked scoliosis gradually developed, because of further tilting of the fifth lumbar vertebra into the original tumor site (Fig. 1-B).

In retrospect it should be noted that the period of non-weight-bearing and cast fixation was probably of too short duration.

CASE 2. A. S., fourteen years old, was admitted to the Nebraska University Dispensary on September 29, 1939, with the complaint of pain in the low back, sudden in onset, following a direct blow in a ball game one year previously. Exercise or a pillow support of the back relieved the pain. There was radiation of pain into the back of the left hip. The patient had a "lump" below the left shoulder blade of three months' duration.

Examination revealed a tall, slender white female, with a trunk inclined to the right. Spine motion was 25 per cent. of normal; marked muscle spasm was noted. A soft, tender, non-pulsating fullness was observed below the left scapula, lateral to the spinous processes. The temperature was 98.6 degrees orally, pulse 84,

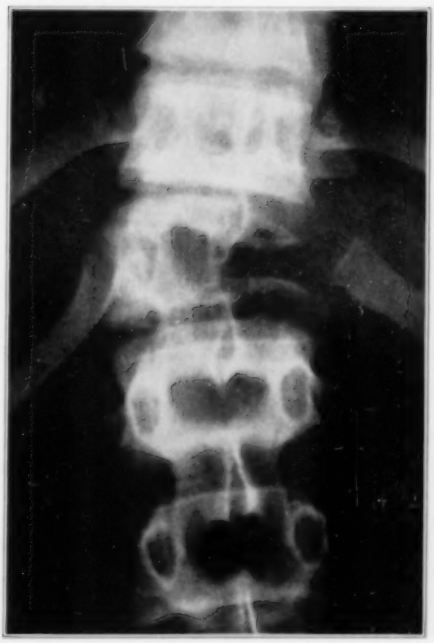

FIG. 2-A
October 2, 1939

FIG. 2-B
Roentgenogram made December 22, 1949, ten years after operation.

respiration 20; blood studies showed 3,800,000 red blood cells and 9,800 white blood cells. The tuberculin and Wassermann tests were negative.

X-ray examination showed a destructive lesion in the left half of the twelfth thoracic vertebra, with smooth edges and some new-bone formation lateral to the spine in the margins of the soft-tissue enlargement (Fig. 2-A). The chest x-ray was negative.

A biopsy was done under general anaesthesia on October 15, 1939, at the Nebraska Orthopedic Hospital. An incision lateral to the erector spinae muscle showed a mass anterior to the ribs, extending between these posteriorly; a thin shell of bone was noted in several areas. The tissue was friable and removal of the specimens was associated with moderate hemorrhage, easily controlled with pressure; closure was in layers.

Histological study revealed considerable hemorrhage throughout the tissue. The deeper portion of the mass consisted of spindle-cell stroma, small round cells, and a large number of giant cells; these had up to fifty nuclei; they were small and vesicular, with sharp, distinct borders. Toward the periphery, spindle cells predominated and a few spicules of osteoid tissue appeared. The tentative diagnosis was giant-cell tumor.

Roentgen therapy, consisting of 1500 roentgens, was given in five doses from November 18, 1939, to January 26, 1939. A corrective body cast was applied. Improvement in bone detail in the tumor site was noted, with a question of further collapse suggested two months later. A spine fusion from the tenth thoracic to the second lumbar vertebra with iliac-bone-graft reinforcement was therefore performed. The patient was immobilized in a body cast for twelve weeks and after that wore a body brace for twelve weeks.

A roentgenogram made on April 10, 1944, showed that correction had been maintained. The patient is now the mother of four children. The last x-ray examination, made ten years after operation (Fig. 2-B), showed that alignment of the spine had been retained.

DISCUSSION

These two cases demonstrate the appearance of giant-cell tumor in vertebral bodies, one occurring definitely before adolescence and therefore prior to epiphyseal closure in the vertebral body, the other occurring late in adolescence. The generally accepted treatment for these lesions has been surgical currettage for accessible areas, with obliteration of the cavity by insertion of bone chips, and roentgen therapy for those not accessible surgically. A combination of roentgen therapy and surgery used by Badgley was reported to produce "poorer results than either alone". The gradual collapse of the body of the vertebra in Case 1, despite improvement in the pathological condition, illustrates either the need for early surgical stabilization of the weakened portion of the spine or a more prolonged period of immobilization fixation if x-ray therapy alone is used. It is our feeling that this collapse could have been avoided by early fusion. The absence of further collapse in Case 2, after early spine fusion, is well illustrated. This stabilization procedure is not to be considered as a direct attack on the tumor itself, but rather as a means of more effective splinting of the diseased area. Roentgen therapy appeared to have no effect on the healing of soft tissue.

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ETIOLOGY OF TRAUMATIC OSTEOPOROSIS *

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It is well known that osteoporosis occurs in bone following a fracture, but there are several features of this type of osteoporosis which have not been adequately described. The osteoporosis first appears in the distal metaphyseal region, often some distance removed from the fracture site[14] (Fig. 1). It involves the distal fragment to a much greater degree than the proximal fragment and the fracture line becomes a sharp line of demarcation (Fig. 2). The cortex of the distal fragment becomes thinner than the cortex of the proximal fragment, with widening of the medullary canal and a more marked decrease in bone density. It is a fact that disuse due to immobilization is one factor in this osteoporosis, but since both fragments are equally immobilized, it cannot be the entire cause. Moreover, osteoporosis is seen in the distal fragment as early as seven days after a fracture, but does not occur for many weeks when a normal extremity is immobilized[1,4,8]. An extremity immobilized for one or two years may not show as much osteoporosis as is commonly seen distal to a fracture within a few months (Fig. 3). In many fractures immobilized for as long as six months, there is little or no osteoporosis in the proximal fragment compared with the non-immobilized opposite extremity, while the distal fragment and the distal bones may show extreme osteoporosis. The marked osteoporosis of the bones of the foot after a fracture of the tibia is a typical example (Fig. 4).

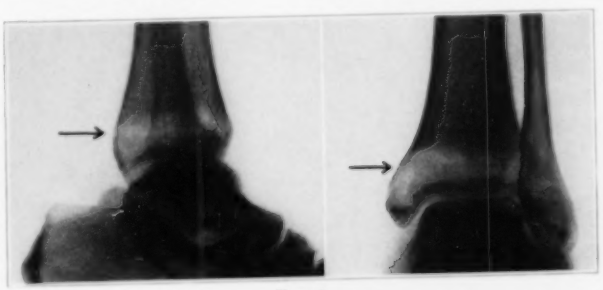

FIG. 1

Roentgenogram of metaphyseal region of a tibia distal to a fracture of the mid-shaft, showing zone typical of early osteoporosis.

It can be assumed that there must be causes other than disuse responsible for this osteoporosis. Greig, as well as Watson-Jones and Roberts, believed that local osteoporosis at a fracture site is due to vascular dilatation from release of histamine or acetylcholine, but this type of osteoporosis is not the same as the more extensive distal osteoporosis and would not cause the sharp line of demarcation seen at the fracture site. We have been unable to produce localized osteoporosis in experimental animals by repeated subperiosteal injections of histamine or acetylcholine in a slowly absorbed base.

After observation of this phenomenon of distal osteoporosis in many fractures, it occurred to the authors that stasis might possibly be the cause. Venous stasis is produced distal to the fracture by the interruption of the medullary vessels, the formation of a hematoma, and oedema from soft-tissue trauma, which retards venous return. If stasis produces bone absorption, this would be most marked in the distal fragment.

Cone described absorption of bone due to congestive hyperaemia as a result of oedema or congestive heart failure and inflammation. He noted that the absorption was

* Reviewed in the Veterans Administration and published with the approval of the Chief Medical Director. The statements and conclusions published by the authors are the result of their own study and do not necessarily reflect the opinion or policy of the Veterans Administration.

FIG. 2

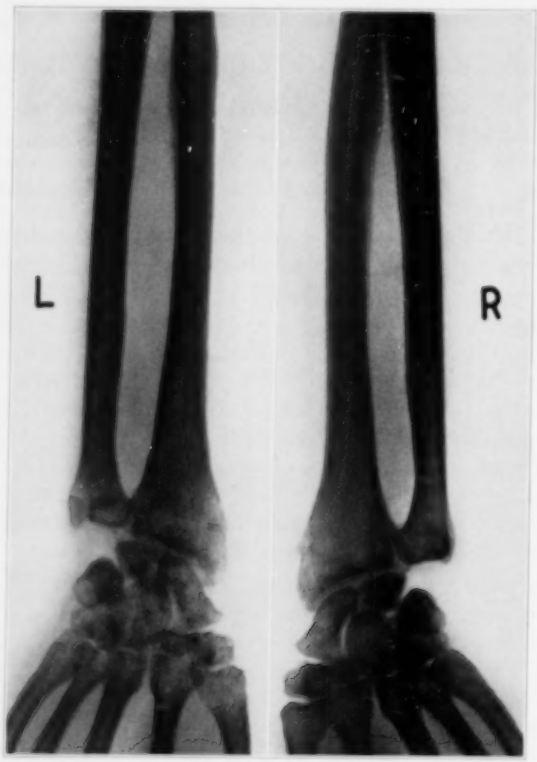

FIG. 3

Fig. 2: Roentgenogram of a fracture of the ulna of twelve weeks' duration, showing marked osteoporosis distal to the fracture line, with minimal osteoporosis of the proximal fragment.

Fig. 3: Roentgenogram of both forearms of a sixty-year-old white man. The left arm had been completely immobilized for twelve months. Note the minimal osteoporosis in the immobilized arm compared with the normal arm. Compare also the minimal osteoporosis in the distal part of the ulna after twelve months of immobilization with the marked osteoporosis distal to the fracture site after twelve weeks in Fig. 2.

mainly in the periosteal region, and was associated with cellular proliferation. Although he did not induce venous stasis, he suggested that it might also result in bone absorption.

The following experiments were done to determine whether or not venous stasis produces osteoporosis and to compare this type of osteoporosis, if produced, with that of disuse and trauma.

PROCEDURE

A: Stasis sufficient to cause soft-tissue oedema was produced by ligation of the major vein of an extremity or by the application of tourniquets. (For details of individual animals and procedures see Table I.) Vein ligations were done through small skin incisions under local anaesthesia. A segment of vein was removed between ligatures and all tributaries in the immediate vicinity were ligated. In some animals the popliteal vein was ligated according to the technique of Pearse and Morton. In others either the femoral or the axillary veins were ligated. Tourniquets were applied by two methods: In one group of animals a segment of umbilical tape was passed subcutaneously around an extremity and tied to produce a constricting band. In another group, an elastic adhesive bandage was applied as a band encircling an extremity. This was changed frequently to prevent skin

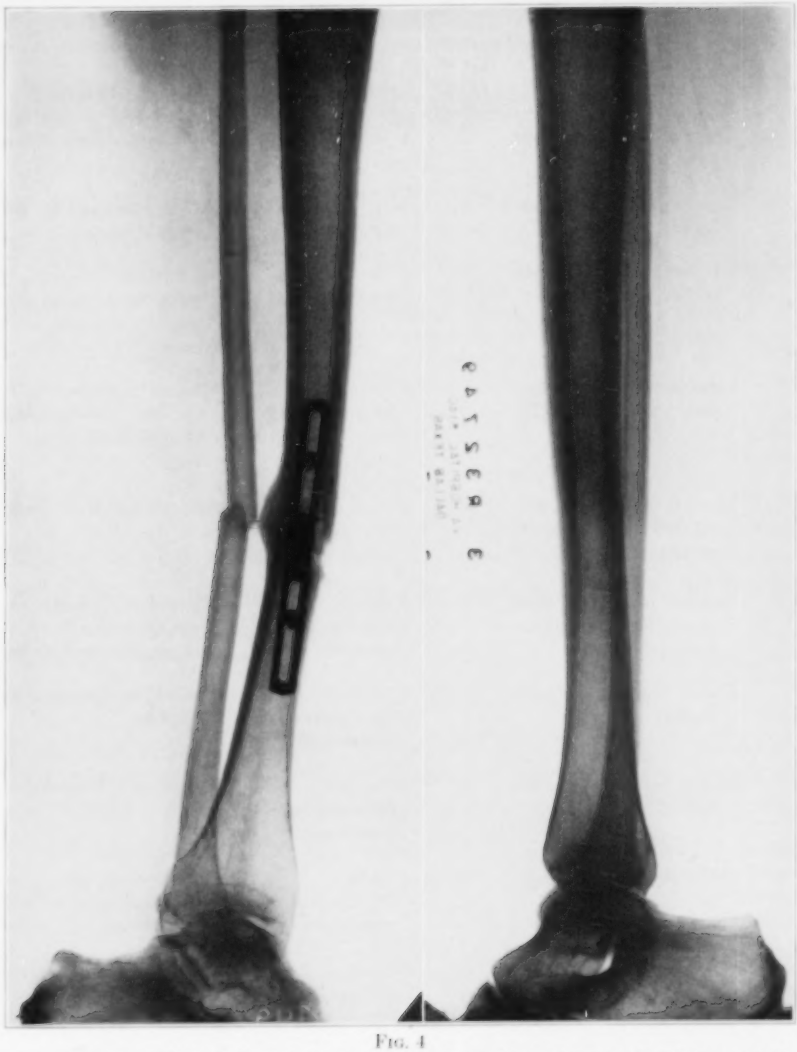

FIG. 4

Roentgenograms of both legs of a patient who had sustained a fracture of both bones of the left leg fifteen months previously. The left leg had been immobilized in casts during the entire period, while the patient used the opposite leg. There was little osteoporosis in the proximal portions of the tibia and fibula on either side, but there was a marked degree of osteoporosis, including the bones of the foot, below the fracture on the injured side.

damage and to maintain oedema. In each animal, the opposite extremity served as a control. The animals walked without limp on the extremities throughout the period of observation; in these animals we were able to study the effect of stasis without associated bone trauma or disuse.

B: Disuse due to immobilization was studied in seven rabbits and five dogs. One extremity of each animal was immobilized either by application of a plaster cast or by a Velpeau type of bandage which held the extremity to the abdomen. The animals remained ambulatory. In two additional dogs Achilles and patellar tenotomies were done. In this series of animals disuse without associated bone trauma or oedema was studied.

C: The effects of bone trauma alone and of bone trauma together with stasis were studied by the production of bilateral fractures of the radius or fibula with ligation of the

TABLE I

Animal	Procedure	No. of Days	Degree and Duration of Oedema	Results
Dog 1	Ligation of femoral vein on left.	51	+ + +	Subperiosteal bone absorption.
Dog 2	Ligation of femoral vein on left.	40	+ + for 3 days only.	No microscopic or roentgenographic changes.
Dog 3	Ligation of superficial vein on left leg.	26	+ + for 5 days only.	Minimal subperiosteal bone absorption. Minimal roentgenographic evidence of osteoporosis.
Dog 4	Ligation of superficial and deep veins in left leg.	31	+ + + for 3 days only.	Minimal subperiosteal bone absorption. Minimal roentgenographic evidence of osteoporosis.
Rabbit 1	Ligation of iliac vein, subcutaneous tourniquet, on left leg.	20	+ + + for duration of experiment.	Subperiosteal bone absorption.
Rabbit 2	Ligation of femoral vein, subcutaneous tourniquet, left leg.	15	+ + for duration of experiment.	Minimal subperiosteal bone absorption distally. No change in proximal end of bone.
Dog 5	Elastic tourniquet, on left foreleg.	7	+ + + for duration of experiment.	Minimal subperiosteal bone absorption.
Dog 6	Elastic tourniquet, on left foreleg.	31	+ + + + for duration of experiment.	Subperiosteal bone absorption.
Rabbit 3	Subcutaneous tourniquet, on left hind leg.	6	+ + + for duration of experiment.	Subperiosteal bone absorption Roentgenographic evidence of osteoporosis.
Dog 7	Elastic tourniquet, on left foreleg.	12	+ + + for duration of experiment.	Subperiosteal bone absorption.
Dog 8	Subcutaneous tourniquet, on left hind leg.	30	+ + + for 7 days.	Considerable roentgenographic evidence of osteoporosis. Subperiosteal bone absorption in both experimental and control leg.
Dog 9	Elastic tourniquet, on left foreleg.	24	+ + + + for duration of experiment except for 2 days.	Roentgenographic evidence of osteoporosis. Minimal subperiosteal bone absorption.
Dog 10	Elastic tourniquet, on left foreleg.	28	+ + + + for duration of experiment.	Subperiosteal bone absorption. Roentgenographic evidence of osteoporosis.
Dog 11	Elastic tourniquet, on left foreleg.	24	+ + + + for duration of experiment.	No microscopic or roentgenographic changes.

TABLE I (*continued*)

Animal	Procedure	No. of Days	Degree and Duration of Oedema	Results
Dog 12	Elastic tourniquet, on left foreleg.	24	+ + + for duration of experiment.	Subperiosteal bone absorption.
Dog 13	Elastic tourniquet, on left foreleg.	62	+ + + + 6 days of oedema, then 32 days without oedema, followed by 24 days with oedema.	Roentgenographic evidence of osteoporosis. No slides made.
Dog 14	Section of ulna removed on left.	25	None	Subperiosteal bone absorption. Enlargement of Haversian canals.
Rabbit 4	a. Both radii fractured, and ligation of axillary vein on right.	15	a. +	a. Better healing of fracture on ligated side. Bone absorption typical of venous stasis and disuse.
	b. Both fibulae fractured. Ligation of femoral vein on right.	15	b. +	b. Better healing of fracture on ligated side. Bone absorption typical of venous stasis and disuse.
Rabbit 5	Both fibulae fractured. Ligation of femoral vein on right.	15	0 to + for six days.	Better healing of fracture on ligated side. No subperiosteal bone absorption.
Dog 15	Both fibulae fractured. Ligation of popliteal vein on left.	21	None*	Better healing of fracture on ligated side. Subperiosteal bone absorption. Roentgenographic evidence of osteoporosis.
Dog 16	Both fibulae fractured. Ligation of popliteal vein on left.	27	None*	Better healing of fracture on ligated side. Roentgenographic evidence of osteoporosis.
Dog 17	Both fibulae fractured. Ligation of popliteal vein on left.	27	None*	Better healing of fracture on ligated side. Roentgenographic evidence of osteoporosis. Subperiosteal bone absorption.
Dog 18	Both fibulae fractured. Ligation of popliteal vein on left.	36	None*	Better healing of fracture on ligated side. Roentgenographic evidence of osteoporosis. Subperiosteal bone absorption.

* Superficial veins patent, soft-tissue oedema not anticipated.

(Table I reproduced by permission from *Surgical Forum*, American College of Surgeons, pp. 436–437, 1951. Philadelphia, W. B. Saunders Co., 1952.)

major veins on one side only (Table I). The fractures were produced through small skin incisions under local anaesthesia with bone-biting forceps. No immobilization was necessary, since the radius and the fibula in dogs and rabbits are adequately splinted by the

interosseous membrane and by the ulna or tibia. The animals continued to walk on the extremities and the effects of disuse were minimal. In this group we were able to study the

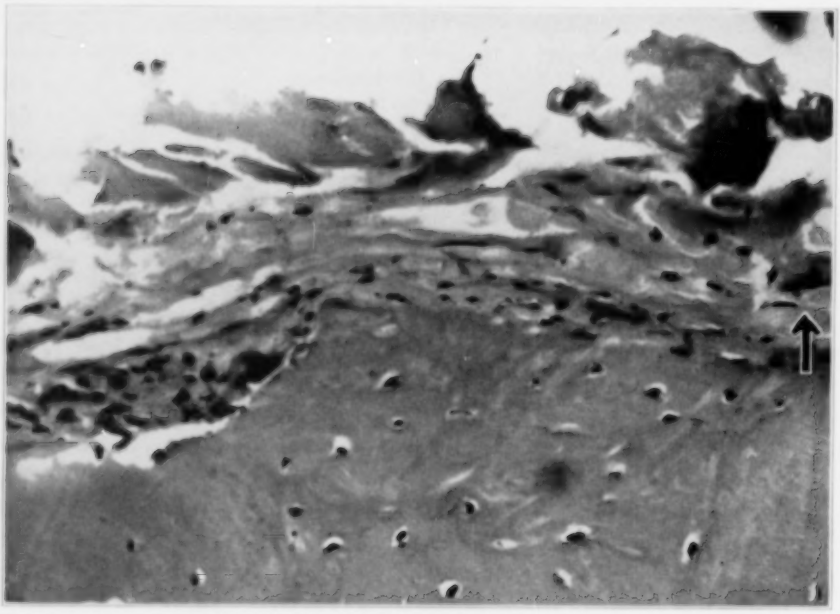

FIG. 5-A

Photomicrograph (× 400) of cross section of control bone in Dog 1, showing periosteum and underlying bone. The arrow shows the thickness of the periosteum.

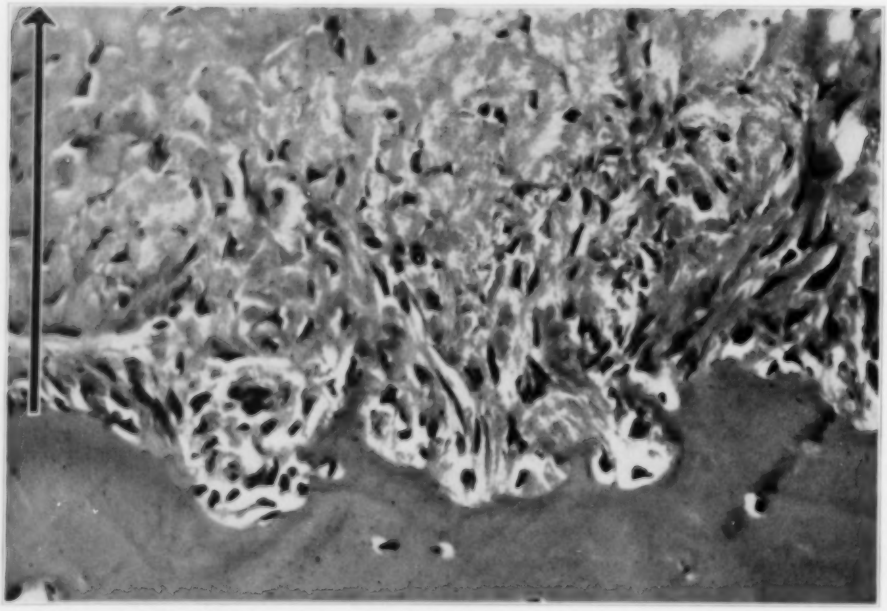

FIG. 5-B

Photomicrograph (× 400) of cross section of bone from opposite leg following stasis of fifty-one days' duration, showing marked cellular reaction, thickening of periosteum, and subperiosteal bone absorption. The arrow shows the thickness of the periosteum.

effects of bone trauma alone in one leg while the opposite leg was used to study the effects of trauma together with stasis.

FIG. 6-A

Photomicrograph (× 90) of cross section of control bone in another dog. The opposite leg had been immobilized for three months.

FIG. 6-B

Photomicrograph (× 90) of cross section from bone immobilized for three months, showing marked enlargement of Haversian canals, thinning of cortex, and relative acellularity.

FIG. 7

Photomicrograph (× 80), showing cross section of periosteum and bone of Rabbit 4 at a site distal to a fracture of fifteen days' duration. This section was taken some distance from the local reaction at the fracture site. Note the subperiosteal bone absorption, increased thickening of the periosteum, and increased cellularity, with enlargement of the Haversian canals and thinning of cortex.

RESULTS

A. *Stasis*

Six days after production of stasis in an uninjured extremity there was roentgenographic evidence of osteoporosis in the most distal portions of the bones. In the stained microscopic sections the changes were found in the subperiosteal zone. There was irregular absorption of circumferential lamellae and peripheral Haversian systems, with replacement by a highly cellular and vascular connective tissue. A basophilic line clearly demarked the uncalcified connective tissue from the bone. As a result of this connective-tissue replacement of peripheral bone, the periosteum was considerably thickened and more cellular. (By comparison the periosteum of the control bone was smooth, thin, and relatively acellular.) There was no change in the size of the Haversian canals; however, the more peripheral Haversian canals in some cases were opened by the bone absorption. The cells were elongated, angular, and deficient in cytoplasm, and the nuclei were hyperchromatic. Occasional osteoclasts were seen along the margin of bone absorption. Between the cells there was an eosinophilic fibrillar substance (Figs. 5-A and 5-B).

B. *Disuse*

Osteoporosis following immobilization was not evident until after thirty days by either roentgenographic or microscopic examination. It was characterized by marked enlargement of the Haversian canals. There was predominant endosteal bone absorption resulting in enlargement of the medullary canal, in contrast to the subperiosteal absorption characteristic of venostasis; there was no replacement of bone by the highly cellular connective tissue observed in the group in which stasis had been produced (Figs. 6-A and 6-B).

C. *Stasis Associated with Trauma*

The osteoporosis distal to a fracture or bone trauma was characterized by the same

highly cellular subperiosteal connective tissue and subperiosteal bone absorption encountered with stasis. There was also the marked enlargement of the Haversian canals and endosteal bone absorption resembling that which we have described as characteristic of disuse, although it appeared much more promptly than in simple disuse. The animals in this group were active throughout the experiment and did not favor the extremities which had been operated upon, so that the changes were probably not brought about by disuse, but their significance is unexplained. Both types of osteoporosis were greater when venostasis was superimposed on the trauma (Fig. 7).

DISCUSSION

These experiments have shown that osteoporosis of disuse and osteoporosis of stasis vary considerably in time and mode of onset and that each presents a characteristic microscopic picture.

Among the normal stimuli to bone production are stress and strain. These are eliminated in disuse, which leads to a decrease in the rate of bone production, with a normal rate of bone destruction. Therefore we consider osteoporosis of disuse a *passive* process. Since the rate of bone absorption is not increased above normal, several weeks or months are necessary for perceptible osteoporosis to appear in a normal bone. We have been unable to produce osteoporosis by disuse alone in less than thirty days in experimental animals. Bone absorption occurs largely in the endosteum and Haversian canals, with minimal subperiosteal bone absorption. The authors believe that endosteal bone absorption may be greater than subperiosteal absorption because of the irregular contour of the endosteum, which presents a greater surface area for absorption.

Osteoporosis of stasis, on the other hand, is an *active* process with an increased rate of bone absorption and a normal rate of bone production. It occurs rapidly, within several days. Microscopically, bone absorption is confined largely to the subperiosteal region and there is no enlargement of Haversian canals. It is the authors' belief that osteoporosis of the Sudeck type may be due to the same active process, since it appears rapidly and is coincidental with soft-tissue oedema.

The active process of bone absorption following stasis results in a highly cellular microscopic appearance, as compared with the relatively acellular appearance of passive osteoporosis of disuse. Starr describes a highly cellular reaction in all tissues following stasis and attributes this to increased protein content in the extracellular fluid, due to increased capillary pressure, and increased oxygen availability due to slight changes in hydrogen-ion concentration. These would result in a higher local metabolism with all the characteristics of inflammation.

In these experiments we have confirmed the findings of Pearse and Morton and of others[2,6,9,10,12,15] that fractures heal more rapidly when stasis is present. Factors which may be partly responsible for this are the increased cellularity previously discussed and the increased protein concentration mentioned by Starr. This increase in local protein would mean a more ready supply for the formation of bone matrix. Osteoporosis is essential to fracture healing[13,16,17] and it is possible that the greater osteoporosis which accompanies stasis is another of the factors responsible for the increased rate of fracture healing.

Osteoporosis distal to a fracture or other bone trauma presents a microscopic picture characteristic of both stasis and disuse, while in the bone proximal to the fracture the changes characteristic of stasis are not found. When additional stasis is superimposed on the trauma, the changes in the distal portion of the bone are even more pronounced. In view of these findings the authors believe that the greater osteoporosis distal to a fracture is due largely to stasis.

CONCLUSIONS

1. The osteoporosis which rapidly appears distal to a fracture is largely due to stasis.

2. It is frequently stated that the marked osteoporosis seen in the foot and ankle following a tibial fracture is due to disuse. The authors feel that disuse plays little part in the production of this osteoporosis for the following reasons:

A. Roentgenographic evidence of disuse osteoporosis is seen only after many months of immobilization, as has been shown both experimentally and clinically.

B. The intensity of bone absorption is too great to be due to disuse. Even after a year or more of disuse, there is seldom the degree of bone absorption seen a few weeks after a fracture.

C. The character of acute osteoporosis following trauma differs from that of disuse osteoporosis in that the former is irregular and involves predominantly the portion of bone distal to the trauma. Osteoporosis of disuse is homogenous and diffuse, involving proximal and distal portions alike.

NOTE: The authors are indebted to T. McDowell Anderson, M.D., Consultant in Orthopaedic Surgery, Veterans Administration Hospital, McKinney, Texas, for his valuable suggestions, and to J. P. North, M.D., Chief, Surgical Service, Veterans Administration Hospital, McKinney, Texas, for his assistance in the preparation of this paper.

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PRELIMINARY SURVEY ON FEMORAL-HEAD PROSTHESES *

BY THE COMMITTEE ON SCIENTIFIC INVESTIGATION OF THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

A year ago the Academy held a symposium on the use of femoral-head prostheses. A considerable amount of interest was shown, not only by the members of this organization, but also by the manufacturers of many different types of femoral-head prostheses. As a result of this, your President suggested that the Committee on Scientific Investigation make a preliminary survey, and it should be stressed now, and will be stressed repeatedly, that this is only a preliminary survey.

In April and May of 1952, all members of the Academy were sent a questionnaire. The questionnaire had nine questions to be answered. Of a total membership of 1,580, 587 returned their questionnaires, or 37 per cent. One member thought that we should stop making surveys.

The first question was "Are you now using femoral-head prostheses?" The question was to be answered "yes" or "no".

Members replying yes	452
Corresponding members	14
Total	466
Members replying no	121
Total	587

Of the total of 587 replies, 452 of our active members replied "yes", and fourteen corresponding members replied "yes", making a total of 466. There were also 121 members who replied "no" and their answers were as carefully studied as were the answers "yes".

The next question was "If you are using them, how many have you used?"

PROSTHESES INSERTED

Members	5082
Corresponding Members	1074
Total	6156
Average number of prostheses per member	11.2
Average number of prostheses per corresponding member	76.7
Over-all average	13.2

The members replying have used, as of October 1, 1952, 5,082 prostheses. Our corresponding members are far more experienced in this new field: fourteen corresponding members have used 1,074. This makes a total of 6,156. The average number of prostheses per member reporting in this survey is 11.2. The average number of prostheses for corresponding members is 76.7—an overall average of 13.2.

The next question was "What is your average time of follow-up?"

AVERAGE FOLLOW-UP TIME IN MONTHS

Members	10.08
Corresponding members	18.7
Over-all average	10.3

This answer was very difficult to obtain without a great many calculations, but these

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 28, 1953.

figures are the most accurate we could obtain. The average length of follow-up in these cases by active members was only 10.08 months. The average time of follow-up by the corresponding members was 18.7 months — an over-all average of 10.3 months.

The next question was: "If you are using a prosthesis, what type or types of prosthesis or prostheses have you used?"

TYPES OF PROSTHESES USED

Judet	267
Eicher	137
Naden-Rieth	69
Frederick Thompson	61
Austin Moore	48
Collison	35
J. E. M. Thomson	30
Roger Anderson	27
Nylon	25
Judet, Vitallium	23
Minneapolis	12
McBride	10
Zimmer	8
Vitallium	8
Judet, stainless steel	7
Lorenzo	6
Acrylic	4
Lippmann	3
And 19 other types	

These are not the total number of prostheses. These figures represent the number of men who replied to this questionnaire. In other words, of 466 who replied "yes", 267 men stated that they were using the original Judet prosthesis; the Eicher prosthesis, 137; the Naden-Rieth, sixty-nine; the Frederick Thompson, sixty-one; Austin Moore, forty-eight; Collison, thirty-five; J. E. M. Thomson, thirty; Roger Anderson, twenty-seven; nylon, unqualified as to type, twenty-five; the Judet made of Vitallium rather than acrylic, twenty-three; the Minneapolis, twelve; McBride, ten; Zimmer, eight; Vitallium, undescribed, eight; Judet of stainless steel, seven; Lorenzo, six; acrylic, four; Lippmann, three. The last line should be emphasized: *nineteen* other types. (The Committee has a record of the details on the different types used.)

The next question was "What incision do you prefer?"

INCISIONS PREFERRED

Gibson	202
Smith-Petersen	111
Anterior	66
Posterior	37
Lateral	23
Anterolateral	16
Watson-Jones	16
Hueter	9
Judet	8
And 14 other types	

In replying, 202 men stated that they used the Gibson incision, calling it the Gibson incision; 111 used the Smith-Petersen incision. As regards the other types, there seems to be a great difference of opinion as to what constitutes a certain incision. I am sure that many of these same incisions are also described under other headings. If we could analyze the patients, we would find that these men were probably using a Smith-Petersen incision, or a posterolateral or so-called Gibson incision, but we have charted the most common ones: anterior, sixty-six; posterior, thirty-seven; lateral, twenty-three; anterolateral, six-

teen; Watson-Jones, sixteen; Hueter, nine; Judet, eight; and fourteen others. Some of these your Committee has never heard of before, and perhaps we should find out what are the usually accepted terms for incisions, either giving their proper name or their proper anatomical description.

The next question was "What indication or indications were there for the use of a femoral-head prosthesis?"

INDICATIONS

Non-union	315
Aseptic necrosis	299
Osteo-arthritis and malum coxae senilis	279
Fresh fracture in aged	190
Fresh fracture in younger patients	24
Pain	21
Congenital dislocation of hip	19
Old slipped capital epiphysis	13
Neoplasm	10
And 21 others	

The most common indication was non-union, listed by 315; aseptic necrosis was next, listed by 299; osteo-arthritis and malum coxae senilis, 279; fresh fractures in the aged, 190; fresh fractures in the younger age group or, according to some men, in any age group, 24; pain, twenty-one; congenital dislocation of the hip, nineteen; old slipped capital femoral epiphysis, thirteen; neoplasm, ten (this should be borne in mind, because in the list of contra-indications we will see some contrasting figures); and twenty-one other indications. Of these twenty-one, the most common ones were a Charcot hip, although on the other hand four men listed a Charcot hip as a contra-indication. Even tuberculosis has been considered by at least two of our members as an indication for the use of a prosthesis. One man said that destruction of the head "due to any cause at any age" was an indication. If we look over this group, we find that the first five indications would cover over 80 per cent. of the total number of indications listed.

The next question asked was in regard to the contra-indications; we think this is most important.

CONTRA-INDICATIONS

Patients too young (less than 40 to 65)	110
Recent infection	107
Tuberculosis	50
Rheumatoid arthritis	33
Osteoporosis	30
Poor risk	27
Insufficient neck	26
Viable head	23
Dysplasia	20
Patients too old	20
Fresh fractures	17
Muscular insufficiency	16
Other arthritis	15
Other satisfactory solution available	15
Debility	15
Lack of cooperation (or mental illness)	11
Obesity	10
Neoplasm	10
Occupation (heavy labor)	9
Neurogenic conditions	9
And 29 others	

The most common contra-indication listed was the patient's belonging to a younger age group, but there seems to be a great variation in what the members consider as the younger group. It ranges anywhere from forty to sixty-five years. The next most frequent

contra-indication was recent infection; then tuberculosis, whether healed or active; rheumatoid arthritis was a contra-indication for thirty-three, but if we go back to the other list there were seven men who stated it as one of their primary indications; osteoporosis, thirty; a poor risk in general, twenty-seven; insufficient neck, twenty-six (although there were several comments under this heading that with a type of prosthesis other than the Judet this would not be considered a contra-indication); a viable hip, twenty-three; dysplasia of the acetabulum, twenty; patients too old, twenty; fresh fractures were a definite contra-indication for seventeen, whereas they were a definite indication for twenty-four; muscle insufficiency, sixteen; arthritis, fifteen; other satisfactory solutions available, fifteen; debility, fifteen; an uncooperative patient (or a mentally ill patient) eleven; obesity, ten; neoplasm, ten; occupation requiring heavy labor, nine; neurogenic conditions, nine (as contrasted to our previous column of ten); and twenty-nine other contra-indications. If we again take the first five or the first ten contra-indications, the number is not so high as in the indications, but the first ten contra-indications comprise about 60 per cent. of the total listed.

The next question was, "What are your complications?"

COMPLICATIONS

Dislocation	158
Infection	80
Fracture (shaft or trochanter)	80
Pain	75
Loose prosthesis	46
Broken prosthesis	38
Limp	27
Absorption of neck	27
Erosion of the acetabulum	19
Subluxation	18
Loss of motion	17
Calcification of capsule	14
Varus deformity	12
Instability	11
Allergy to material	11
Thrombophlebitis	9
None	8
Exacerbation of arthritic condition	6
Myositis ossificans	6
Trochanteric bursitis	5
Fit of prosthesis too tight (squeaking)	3
Flexion deformity	3
Judet apparatus found not suitable	3
Sciatic palsy	2
Rehabilitation difficult	2
"Many"	2
And 10 others	

Dislocations were reported by 158 in the survey, infection by eighty. This seems far too high a percentage of infections for a group of certified orthopaedic surgeons. Fracture of the shaft or fracture of the trochanter in inserting the prosthesis was listed by eighty; postoperative pain markedly increased to the point of disability, seventy-five; a loose prosthesis, forty-six (it should be emphasized that this figure means not forty-six patients, but forty-six men reporting that this has happened at least once, and many of them report five and ten of these various complications); broken prosthesis, thirty-eight; marked increase in limp, twenty-seven; further absorption of the neck, twenty-seven; erosion of the acetabulum, nineteen; subluxation, eighteen; further loss of motion up to and including complete loss of motion, seventeen; calcification of the capsule, fourteen; varus deformity,

twelve; instability to the point where the patient had to use crutches or a cane or both, eleven; allergy to material, and this was chiefly nylon, eleven; thrombophlebitis, nine; eight reported they had had no complications and we think they have been extremely lucky; exacerbation of arthritic condition, six; myositis ossificans, six; trochanteric bursitis, five; too tight a fit, giving a squeaky joint, three; flexion deformity, three; Judet apparatus found not suitable because of insufficient neck, three; sciatic palsy, two; rehabilitation difficult, two; "plenty", two; and ten other major complications.

Once again it should be emphasized that this was a preliminary survey to find out how active our members are in using some type of hip prosthesis. The questionnaire did not ask for results. We feel it is far too early to ask for results.

ANALYSIS OF "NO" ANSWERS

No comment	57
Planning to use but in future	21
Cases too few and follow-up too short	9
Awaiting this report	8
And 15 others	

It should be remembered that 121 answered this questionnaire "no, they had not used a femoral-head prosthesis". Fifty-seven made no comment or answered "no", some of them very emphatically. Twenty-one stated that they had not yet used a prosthesis but would use one in a suitable case. Nine reported that they had too few cases or that the time of follow-up was too short, so that they did not feel they wanted to add their statistics to this survey; eight reported they were awaiting this report to see whether they should or should not use femoral-head prostheses; and there were fifteen other answers.

Listed below are the impressions which your Committee felt they could obtain from this survey. This is a simplified list, and it should be noted that every questionnaire which was returned was completely cross-checked to make this survey.

IMPRESSIONS FROM THE SURVEY

1. Too many prostheses are being used for too many indications.
2. The trend is toward abandonment of the Judet prosthesis made of acrylic.
3. There is increased use of intramedullary types of prostheses.
4. The Gibson approach is the most popular.
5. Indications are becoming more definite.
6. The complications are too great.
7. The survey is to be continued until there is a follow-up time of three to five years. An attempt to evaluate results can then be made.

In regard to Impression 2, if the Judet prosthesis is continued at the present time, the preference is for one of the metallic modifications of the Judet prosthesis rather than the original acrylic type. As indicated in Impression 4, the Gibson approach is the most popular; we have no comments to make as to whether it is the best, the worst, or in between; this report indicates only that it is the most popular. Under Impression 5, the indications for the use of the femoral-head prosthesis are becoming more definite and we feel that with further use we can narrow down the wide field of present indications. Impression 6 is the most important; the complications listed in this preliminary survey have been appalling and if a procedure cannot be done with fewer complications than those recorded, something is wrong. Impression 7 is that the survey should be continued until the follow-up time is from three to five years, as only then may we have the right to attempt to evaluate results.

The ninth inquiry on the questionnaire was in regard to further instructions for this Committee or the need for other information which the Committee should obtain. We had fifty-two replies. Some of the suggestions were very practical, and I am sure the Committee

will take them under advisement. The most common one was that this or a similar investigation should continue for a period of from five to ten years. The survey not only should but will be correlated with the work of the Fracture Committee, particularly in connection with the use of these prostheses in the treatment of fresh fractures. This survey should also be correlated with the work of the Committee on Instruments and Gadgets. Many of the prostheses which are now standard we first saw in the Exhibition Hall in our Gadget Exhibit, and we are sure that you will see more of these.

Many men have said that the promiscuous use of the device should be curtailed and that we should discipline the manufacturers and salesmen until better evaluation has been made. We do not see how we can discipline the manufacturers and salesmen. We think rather that each individual as a member of the Academy should discipline himself.

Respectfully submitted,

JOHN J. FAHEY, M.D.
DONALD E. KING, M.D.
PAUL LIPSCOMB, M.D.
DONALD B. SLOCUM, M.D.
CLAUDE N. LAMBERT, M.D., *Chairman*

DISCUSSION

DR. DUNCAN MCKEEVER, HOUSTON, TEXAS: The multiplicity of design of these prostheses might have been avoided with a little more basic investigation in structural design. Any structural engineer who becomes acquainted with the problem can immediately point out faults in these prostheses and is able to predict where they will break.

About the subject of absorption of the neck: If the direction of stress applied to the end of the neck, where the weight-bearing must be, is constant, absorption does not take place. If there is constant variation in that direction, even though it is very slight, absorption will take place.

Allergy to nylon, in my opinion, does not exist, but nylon is not an absolutely inert material. We call it inert; however, we use the term "inert" rather loosely. Nylon, on the surface which is exposed in a prosthesis, is inert for all practical purposes; nylon sheet, if used in the knee, is equally inert. However, if you start grinding off very fine fragments and dust from the surface of the nylon, you begin to multiply the surface area exposed to the tissue many times and, when that surface area is increased, the small amount of reaction to it is multipled in the same proportion. If you take a block of nylon and drop it into the abdominal cavity of an animal, there is no reaction, no cellular infiltration, and no scar-tissue formation. Grind up that same amount of nylon into a powder or into very small fragments and put it into the abdominal cavity of an animal, and the reaction to it is violent. That is true of acrylic, it is true of stainless steel, and it is true of almost every substance known.

There is just one piece of advice which I should like to give to the men who have not used a prosthesis. Do not pick the most hopeless, difficult case, an old patient or one who has had five or six operations, for your first prosthesis. Take an easy case, such as a fracture without any complications, for your first case.

EDWARD HARLAN WILSON

1891–1952

On December 21, 1952, Edward Harlan Wilson died suddenly in Columbus, Ohio, at the age of sixty-one, at the height of his career.

Son of a well-known and able Ohio surgeon, he was born in Columbus on May 31, 1891. He was educated in the grade and high schools of that city and, after taking his Bachelor of Science degree at Dartmouth College in 1915, he entered Harvard Medical School. After graduation, he served as intern on the Surgical Service at the Massachusetts General Hospital during the years 1920 to 1922. He then turned to orthopaedic surgery, serving on the House Staff in this specialty at the Massachusetts General Hospital and Boston Children's Hospital.

Having completed his training in orthopaedic surgery, he returned to his native city in 1924 and there entered private practice. He immediately joined the teaching staff of the College of Medicine of the Ohio State University and continued to work in that institution until his untimely death, at which time he was Professor of Orthopaedic Surgery and head of the department in the Medical School. He was also chief of the orthopaedic service in the University Hospital, the Children's Hospital, and the Mount Carmel Hospital of Columbus.

In 1942 he served a term of six months as Resident Director of the American Hospital in Britain and was an Honorary Fellow of Exeter College, Oxford, England. He was a member of The American Orthopaedic Association and a Fellow of The American Academy of Orthopaedic Surgeons and the American College of

Surgeons; he was an active member of the leading orthopaedic societies in this country and of the Robert Jones Club of England.

A regular attendant at orthopaedic meetings, Harlan went to listen, not to talk from the floor. He was not a frequent contributor to surgical literature and this, with his reluctance to take the floor in meetings, was due to his innate modesty (a surprising, but not unpleasing quality in many other men of large and imposing stature). With him, there was no lack of ideas and information; the opposite prevailed. Many a lesser man would have lost no time in imparting his views to his fellows. Harlan Wilson will be remembered for deeds rather than words.

His diversity of interests is indicated by the fact that he was an artist of considerable ability, who loved travel and reading. He served on the Advisory Committees on Cerebral Palsy, Poliomyelitis, and Crippled Children and was Chairman of the Professional Advisory Committee on Rehabilitation. In addition to medical associations, he held membership in several clubs and fraternal organizations and was a director of the Midland Mutual Life Insurance Company. In other words, he was not only a great teacher and practitioner of orthopaedic surgery, but an important citizen in his home town.

To many of us he was a good companion and we shall miss him for a long time. We extend our sympathies to his wife and children.

LETTER TO THE EDITOR

Dear Sir,

In perusing the current literature with which this journal is concerned, we note that an ever increasing number of its articles deals with problems pertaining to research on "stress" and the so-called "adaptive hormones" (ACTH, STH, corticoids, and adrenergic substances).

We are writing you because, in our opinion, the success of research in this complex and rapidly developing field largely depends upon the prompt availability and evaluation of relevant publications, a task for which we should like to solicit the assistance of your readers.

In 1950, our Institute initiated the publication of a series of reference volumes entitled "Annual Reports on Stress" (Acta, Inc., Medical Publishers, Montreal) in which the entire current world literature is surveyed every year (usually between 2000 and 4000 publications). Up to now, we had to compile the pertinent literature partly from medical periodicals, monographs, abstract journals and partly from reprints sent to us by the authors themselves. Of all these, reprints proved to be the best source of data which we felt deserved prompt attention in our annual reports. Hence, in the past, we had sent out several thousand individual reprint requests to authors of whom we knew that they were currently engaged in research on stress and allied topics. Even this procedure did not give us the wide coverage which would be desirable, because it is materially impossible to contact all these authors individually and it often takes too much time to get the requested reprints.

It is evident that in order to ensure prompt inclusion of publications in the annual reports, these surveys must develop into a cooperative effort between the authors of original papers and the reviewers. This cooperation was greatly enhanced of late by the publication of announcements, in several medical journals, encouraging investigators interested in stress research to send us their reprints for this purpose as soon as they become available.

We should be grateful if, by the publication of this note, you would also bring this problem to the attention of your readers.

We are, Sir,

Very sincerely yours,

Hans Selye, M.D., Ph.D., D.Sc., F. R. S.(C),
Professor and Director of the Institute of
Experimental Medicine and Surgery.

Alexander Horava, M.D.,
Co-author of the "Annual
Reports on Stress".

Proceedings

THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

The Twentieth Annual Meeting of The American Academy of Orthopaedic Surgeons was held at the Palmer House in Chicago, January 24 to 29, 1953, under the Presidency of Dr. Francis M. McKeever.

The Scientific Program was opened on January 25, 1953. As arranged by Dr. H. Herman Young and his committee this program was exceptionally interesting and valuable. The following are summaries of the papers presented:

Sunday, January 25, 1953

The Diagnosis and Treatment of Giant-Cell Tumors of Bone. Dr. Edward L. Compere [1] called attention to the high frequency of error in the diagnosis of giant-cell tumor of bone, the lesion often being mistaken for non-osteogenic fibroma, unicameral bone cyst, aneurysmal bone cyst, chondromyxoid fibroma of bone, benign chondroblastoma, and localized osteitis fibrosa. He listed ten characteristics of the tumor: age (average, 28.4 years); location (end of long bones); local pain; tenderness and palpable swelling; thin, expanded cortex; a circumscribed osteolytic expansible lesion, rarely periosteal reaction; histological evidence of greater stromal-cell growth and multiplication than in other tumors containing large numbers of giant cells; acid but no alkaline phosphatase present in stromal cells, in contrast to other giant-cell lesions, the stromal cells of which contain only alkaline phosphatase. Unless several of these are present in a given neoplasm of bone, the diagnosis of giant-cell tumor is not justified. Biopsy of a lesion should include not only the periphery of a tumor but deeper portions as well, since giant cells can be seen in the periphery of a number of tumors other than giant-cell tumors. As to treatment, he pointed out that the degree of success of x-irradiation is for the most part inversely proportional to the size of the tumor. The treatment should be surgical when it is feasible, especially in the larger tumors; most giant-cell tumors may be satisfactorily treated in that way followed in some instances by x-irradiation. The reports of two interesting cases were presented in which success resulted from radical surgery after x-irradiation had failed.

Chondromyxoid Fibroma of Bone: Report of Two Cases. Dr. David C. Dahlin [2], Dr. Arthur H. Wells [3], and Dr. Edward D. Henderson [4], reported two cases of this apparently uncommon, recently discovered benign tumor of bone. First described by Jaffe and Lichtenstein in 1948, this tumor seems to have been recorded through reports of only twelve cases, in each of which the clear-cut features of a benign chondromyxoid neoplasm are unmistakable. Nothing appears to have been added to the original description.

Clinically, local pain and a tender palpable mass are the usual findings. Curettage with or without bone grafts to fill the defect has been uniformly successful. Roentgenographically, the circumscribed zones of diminished density may be mistaken for fibrous dysplasia, bone cyst, and enchondroma.

Solitary Unicameral Bone Cyst. Dr. George J. Garceau [5] and Dr. Charles F. Gregory [6] reviewed the history, physical and roentgenographic findings, and the results of treatment in twenty-seven cases of their own and in 313 cases in the literature. They had found that the incidence of recurrence of cysts treated before the age of ten is considerably higher than that when treatment is carried out after that age. In fifty-five patients with bone cysts, who had been treated under ten years of age, thirty-five cysts healed and twenty recurred, whereas in thirty-six patients who were treated after ten years of age only three of the cysts recurred. In 78 per cent. of the reported cases, the lesion developed in the humerus or femur. Fractures occurred in 63 per cent. of the authors' cases and in 15 per cent. of these the cysts healed without open operation. They consider that this lesion is a definite entity differing from other members of the fibrocystic disease group, occurring most frequently in the long bones between the ages of nine and fourteen, and that it is as common in males as in females. While the roentgenographic appearance is characteristic, the lesion must be differentiated from fibrous dysplasia, non-osteogenic fibroma, giant-cell tumor, enchondroma, neurofibroma, and lipoma.

Subperiosteal Giant-Cell Tumor. Dr. Paul C. Thompson [7] reviewed present-day knowledge of a benign tumor variously designated by the names "subperiosteal giant-cell tumor", or by the terms "ossifying sub-

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periosteal hematoma", or "aneurysmal bone cyst". He reported a series of nine cases. He considered the lesion to be definitely not a true giant-cell tumor on grounds of age, location (commonly found along the diaphysis of long bones, the femur and humerus being most frequently involved; it may occur in the metaphysis and in most bones), roentgenographic, and microscopic appearance. Rather, he classified it as a probable reparative process following periosteal vascular disturbance. Seventy-one per cent. of the patients gave a history of trauma. The tumor may arise from a rupture of periosteal or nutrient vessels with formation of a pseudo-aneurysm. The x-ray and gross microscopic appearances are characteristic. Excision is successful.

Reticulum-Cell Sarcoma of Bone. Dr. John C. Ivins [8] and Dr. David C. Dahlin [9] reviewed the knowledge of this relatively recent addition, as an entity, to bone-tumor classifications. They reported a series of patients with such tumors which had been diagnosed by biopsy and which had been subjected to definitive treatment at the Mayo Clinic. Amputation and subsequent x-irradiation were most frequently employed; the prognosis seemed to be significantly better than in most other primary malignant tumors of bone. Treatment by various combinations of x-irradiation, surgery, or both (including one case treated only by Coley's toxins) resulted in a five-year survival rate of 35.7 per cent.

In the discussion of the foregoing papers on bone tumors, Dr. Mary Sherman [10] expressed the feeling that no one now would disagree with Dr. Compere's contention that it is foolhardy to attempt a treatment of large giant-cell tumors by x-irradiation alone. She went further and said that all accessible giant-cell tumors should be treated surgically.

She felt that the paper of Dr. Dahlin, Dr. Wells, and Dr. Henderson on chondromyxoid fibroma of bone is especially apt in pointing out the importance of good pathological studies. Here is a lesion with a name which is much more formidable than its behavior. Whether one considers it as a distinct entity and a benign one, or as a low form of chondrosarcoma, it is important that it be identified, since it is susceptible to cure. However, she wondered about the wisdom of curettage of any tumor of chondromatous origin. Such tumors have a way of reacting disagreeably to any disturbance. Since this is such a real danger, she felt one is not justified in recommending anything less than total excision.

In her judgment, Dr. Thompson in his paper on subperiosteal giant-cell tumor has made a timely discussion of a condition which receives too little attention. It is not a common condition and it is surprising to see incontrovertible evidence that the lesion can start entirely outside a bone, for the very few she had seen appeared to arise within. Perhaps either location may be the site of origin. It is interesting that trauma seems to be important in initiating these lesions. It is, however, hard to understand, if it is the principal factor, why these tumors are not more common and why they do not appear with great regularity in such sites as the tibial shaft, patella, and olecranon, which are always being bumped. Furthermore, why do they not appear following fractures or surgical procedures which, in addition to inflicting trauma, also rupture vessels? It would be interesting to make investigations on these patients from the point of view of the hematologist to see whether "bone aneurysms" represent an unusual response to trauma which is dependent upon a constitutional disturbance. The terms "subperiosteal giant-cell tumor" and "ossifying subperiosteal hematoma" should surely be discarded. As Dr. Thompson pointed out, the lesion has absolutely no relation to a neoplasm. It has even less resemblance to an organizing hematoma. Although we do not know the etiology of this lesion, the term "bone aneurysm" describes its appearance and behavior and has the virtue of not being completely misleading.

She said, regarding the paper by Dr. Ivins and Dr. Dahlin, "I am slightly disturbed to discover that others find the diagnosis of reticulum-cell sarcoma so easy that they consider reticulum stains of no help. There are perhaps many tumors in which the diagnosis is clear with routine stains, but I still like to see those fibers. Even then I find it troublesome to state with certainty that a given lesion is surely a reticulum-cell sarcoma. However, I think the most important point of this paper is the idea that, although most such tumors are highly radiosensitive, it is probably not wise to rely on x-irradiation alone. I am sure that surgical excision is best, although I feel that amputation can often be avoided by wide local resection."

In closing, she emphasized that the symposium as a whole underlined, as it should, the extreme importance of establishing an accurate microscopic diagnosis before definitive treatment is planned. It showed, too, especially in relation to the giant-cell tumors and bone aneurysms, that, in order to make a diagnosis, an adequate biopsy specimen is essential.

Monday, January 26, 1953

The Clinical Significance of Retention of Foetal Position of the Limb. Dr. Carl E. Badgley [11] and Dr. Sylvester J. O'Connor [12] believe that many of the deformities observed in the newborn or in early infancy represent retention of the foetal position. Some of these are physiological postural faults and require no

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treatment since they disappear with growth, while others are pathological and require early recognition and treatment to prevent serious deformities. The minor physiological deformities include torsion of the legs, bow legs, knock knees, and metatarsus varus or adductus. The pathological deformities include congenital dislocation of the hip, club feet, dislocation of the knee, and abduction deformity of the hip. The physiological deformities are due to retention of foetal position alone, while in the pathological conditions there exists an intrinsic failure in the timing of development which in turn produces an environmental fault manifested as a retention of foetal position, failure of rotation, and the like. Poor sleeping and sitting positions frequently contribute to these deformities and must be corrected. It is important to determine early whether the deformity is one which may be expected to correct itself with growth or one which requires prompt and active therapy.

In discussion, Dr. Charles O. Bechtol [13] suggested that the shape of the foetal membrane, which is known to vary, may be a factor in the mild or physiological deformities.

Dr. M. Beckett Howorth [14] stated that many of the deformities, even the physiological ones, may persist in adult life and that therefore they should be treated in infancy when the tissues are plastic. He stressed the importance of correcting faulty sleeping positions as well as the use of stretching, exercises, and splints.

Dr. J. Albert Key [15] expressed doubt as to the significance of foetal position, since the foetus moves around *in utero*. In his experience the majority of these conditions, such as tibial torsion, correct themselves with growth without treatment.

Dr. Badgley in closing reiterated that the pathological types must be recognized and treated, but that the physiological ones usually correct themselves.

Intra-Articular Hydrocortisone in Arthritis and Allied Conditions: A Summary of Two Years' Clinical Experience. Dr. Joseph Lee Hollander [16] reported the results of 7,352 injections of joints, bursae, or tendon sheaths in 723 patients. Of these 3,757 injections had been carefully analyzed, the remainder were sampled and were found to show the same results. Under conditions of ordinary office asepsis, injections were given with a 20-gauge needle, usually without novocain. Virtually all accessible joints were injected from the hip to the interphalangeal joints of the hands. The dosage, which was empirical, ranged from 5 milligrams in the small joints to 25 or 37.5 milligrams in the hip and knee. Repeated injections were given, as many as thirty-eight to a single patient, at intervals of from one to four weeks. Only two joints were injected at one time in order to avoid systemic effects. Results were rated as successful if there was unequivocal improvement lasting at least three days, while anything less was rated a failure. In 249 cases of rheumatoid arthritis, the failure rate was 6 per cent., while the average amelioration of signs was 60 per cent., and the average duration of relief, eight days. In 231 cases of osteo-arthritis the over-all failure rate was 13 per cent. Results in the hip were poor with 53 per cent. failures, while in the knee they were good with 10 per cent. failures. The average duration of relief was two weeks, but in fourteen patients with osteo-arthritic knees relief persisted for ten months or more. In gout and acute traumatic arthritis the results were good. In tennis elbow, peritendinitis crepitans, trigger finger, de Quervain's disease, and acute subdeltoid bursitis, relief was also obtained. In chronic subdeltoid bursitis about half of the injections were failures, and no benefit was noted in the shoulder-hand syndrome. Some variation in response to injections was noted; some patients did well initially but failed to respond after repeated injections, while others responded poorly at first only to obtain good relief subsequently. Untoward reactions occurred in 173 or 2 per cent. of the total 7,352 separate injections. Most of these were temporary local exacerbations of joint inflammation, lasting two to seventy-two hours; but in four local urticaria developed, and fifteen had bizarre, unexplained, transient weakness. There was one infection in a patient with acne which was controlled with antibiotics.

Onychocryptosis (Ingrown Toenail): Its Etiology and a Plea for Conservative Treatment. Dr. David I. Schwartz [17] believes that growth of the nail edge into the soft tissues does not occur in this common condition, but that the symptoms are due to an infection about the nail margin, resulting from improper trimming of the nails with unsterile instruments. This infection is made worse by the moisture and dirt commonly present on the feet. The author makes a plea for conservative treatment to control the soft-tissue infection, including moist heat, rest, and the use of a cut-out shoe followed by careful supervision until the cut nail edge has grown beyond the skin margin. The use of cotton beneath the nail edge he considered to be of no value.

In discussion, Dr. John R. Cobb [18] concurred in recommending conservative treatment but favored the use of cotton held beneath the nail edge with collodion. Furthermore, in his opinion, various forms of surgery are occasionally necessary.

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Dr. Rex L. Diveley [19] expressed the opinion that faulty weight-bearing caused by pronation is the most common cause of distortion of the nail plate in this condition. He too favored the use of cotton beneath the nail edge and surgery for the severely deformed nail to prevent recurrence. He stressed the correction of faulty weight-bearing by proper supports.

Fractures of the Hip in Children: Treatment and Results. Dr. J. Alvin Ingram [20] and Dr. Borden Bachynski [21] discussed the experience of the Campbell Clinic with twenty-four fractures of the hip in children treated by the Staff of the Clinic. All fractures occurred in patients under seventeen years of age. The patients were divided into four anatomical groups: transepiphyseal with six patients, transcervical with eleven patients, cervicotrochanteric with five patients, and intertrochanteric with two patients.

In the transepiphyseal group the treatment of choice is gentle closed reduction with internal fixation by two or three Knowles pins. The pins were considered preferable to the three-flanged nail. If the femoral head has been dislocated, reduction must be open and non-weight-bearing must be prolonged. In the transcervical and cervicotrochanteric groups, gentle closed reduction and Knowles pin fixation are favored where fragments are separated. If the fragments are not separated, a Hoke-Martin traction cast or a Whitman abduction cast is employed. The Hoke-Martin traction cast was also used for the intertrochanteric group.

Results in the transepiphyseal group with dislocation of the femoral head have been uniformly poor (five of the six gave poor results) largely because of avascular necrosis. In the transcervical and cervicotrochanteric groups, results were satisfactory in thirteen of sixteen.

Bony union occurred in twenty-one of twenty-four cases within six months of the institution of treatment. Of seventeen patients followed more than one year, avascular necrosis developed in six between ten and twelve months, (four of these were in the transepiphyseal group and in each the head was dislocated by the injury, two were in the transcervical group).

The discussion was opened by Dr. Russell F. Sullivan [22] who reported that his experiences in the orthopaedic department at the Boston City Hospital have coincided remarkably closely in many ways with those of Dr. Ingram and Dr. Bachynski. In this series of twelve patients treated between 1934 and 1952, all intracapsular fractures, except the epiphyseal, were included; there were no intertrochanteric fractures.

There was one fracture through a solitary bone cyst. These fractures in children are only 1 per cent. of the adult total. Most of the fractures resulted from severe trauma. The average age was twelve years; in the series, the proportion of males to females was 3 to 1. The location of the fractures was almost entirely in the distal third of the neck. Paroni's method of treatment had been tried.

The double plaster spica was used for fixation after reduction in five; the Smith-Petersen nail was used in three; balanced traction in two; bone-grafting and spica in one; and bone-grafting in one. Difficulty had been encountered in introducing the Smith-Petersen nail. Over-all results were relatively poor: four were excellent, two were fair, and four were poor.

Dr. William T. Green [23] reported a series of eight cases with a comparable experience. In only one patient did aseptic necrosis develop. All of the eight cases were the result of much less severe trauma.

Complications and Failures of the Operative Treatment of Intertrochanteric Fractures of the Hip. Dr. G. Mosser Taylor [24], Dr. Alonzo J. Neufeld [25], and Dr. Vernon L. Nickel [26] had analyzed 123 serious complications found in a review of a large series of intertrochanteric fractures treated by open reduction and fixation with a Neufeld femoral-nail plate at the Los Angeles General Hospital from June 1948 to June 1952; 1,469 intertrochanteric fractures of the hip had been so treated. Vascular, pulmonary, and other complications, such as sepsis, were not included in this study. The complications were (1) penetration of the nail through the head or neck for various reasons, (2) faulty reduction or subsequent loss of reduction, resulting in varus, valgus, or rotational deformities, (3) delayed union and breaking of the nail, (4) less common complications such as abandonment of internal fixation at operation because of excessive comminution, non-union, failure of the patient to ambulate postoperatively because of pain, senility, or psychosis, bone destruction due to tabes dorsalis, and aseptic necrosis. In the two patients with aseptic necrosis, one had a fracture of the base of the neck which healed successfully, while the other had a true intertrochanteric fracture which had been treated by the closed method. These failures were considered to result from (1) errors in surgical technique or judgment, (2) inadequate postoperative management, (3) endogenous factors such as osteoporosis, paralysis agitans, tabes dorsalis, and psychosis. Union required five to seven months to occur in patients operated upon as compared with three to four months in those treated with closed methods.

In discussion, Dr. Eugene L. Jewett [27] expressed preference for the three-flanged nail and plate form

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of internal fixation and stressed the importance of keeping the nail low in the head of the femur in order to avoid the risk of traumatic arthritis in the weight-bearing area in the event of the nail's penetrating the joint.

Dr. Edwin F. Cave [28] pointed out that the operation should be attempted only if it promises to reduce morbidity and mortality and to promote early discharge from the hospital. With excessive comminution and osteoporosis as shown in good preoperative films, these objectives are not attainable and the operation is contra-indicated.

Regional Stress Angiography. Dr. Jesse T. Nicholson [29], Dr. H. P. Kopell [30], and Dr. Frank A. Mattei [31] reported postmortem experiments designed to determine the effect of the "frog-leg" position on the circulation of the hip. An opaque material, in a fast-setting plastic, was injected into the aorta of nineteen cadavera within twenty-four hours of death at pressures close to the mean arterial pressure during life. With one limb held in the "frog-leg" position and the other held in a neutral position, the material was injected. When the plaster had set, both limbs were placed in the neutral position and x-rays were taken which permitted a comparison of the filling of the arterial tree on the two sides. The following conclusions were presented: (1) the "frog-leg" position appeared to interfere with arterial filling in the hip area; (2) the effect varied directly with abductor resistance; (3) the medial circumflex, lateral circumflex, and the profunda femoris arteries were affected; (4) abductor tenotomy minimized the impairment of circulation associated with the "frog-leg" position.

In discussion, Dr. J. Hamilton Allan [32] pointed out the need for localizing the point of obstruction by dissection or other means.

Dr. Alfred R. Shands, Jr., [33] questioned whether adductor resistance in the "frog-leg" position would last long enough to do permanent damage to hip circulation, but he pointed out that we do not know how long it takes for circulatory changes such as this to affect the nutrition of bone and cartilage. He reported that in forty hips treated by manipulation and immobilization in the "frog-leg" position since 1940, only six or 15 per cent. showed aseptic necrosis and that these had good functional results after two to ten years' follow-up.

Tuesday, January 27, 1953

Direct Surgical Treatment of Arteriosclerosis. Dr. Ormond C. Julian [34], Dr. William S. Dye [35], Dr. John Olwin [34], and Dr. William Grove [37] reviewed recent trends and advancements in arterial surgery. Technical advances in blood-vessel anastomosis and grafting and in the use of heparin have made possible direct surgical attack upon local obstructions to the arterial flow through main channels. Heretofore attention has been necessarily directed largely toward improving collateral circulation by sympathectomy. Restoration of arterial flow may be accomplished in two ways: either by resection of the diseased intima and the internal portions of the media of the obstructing main arterial segment or by resection of the entire segment followed by replacement with a vein or artery graft. Autogenous and homologous vein grafts were discussed for use in the superficial femoral artery, and a graft taken at necropsy from a young adult was used to replace the aortic bifurcation. The success of an arteriectomy depends upon continuous heparinization and is dependable only in such large or medium channels as the lower end of the aorta, the common iliac vessels, or the superficial femoral artery.

Clinically, segmental occlusion in arteriosclerosis is ordinarily manifested by intermittent claudication; other common complaints in arteriosclerosis such as rest pain, cramps, coldness, pallor, and paraesthesia are absent. There is loss of palpable pulsation and a marked fall in the oscillometric indices on the limb.

Arteriography establishes the diagnosis, localizing the obstructing segment and determining its extent, as well as the condition of the collateral circulation and the condition of the main channels proximal and distal to the obstruction.

Obstruction commonly occurs at certain anatomic sites, the aortic bifurcation, the femoral bifurcation, the adductor hiatus, and the popliteal artery. It may be a late as well as an early complication of fracture.

An impressive group of cases with details of operative technique was presented. Results have been encouraging.

In discussion, Dr. J. A. Key [15] asked if Achilles tenotomy was not a simpler and more effective proce-

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dure. Dr. Julian replied that the arterial operations were better in that they prevented propagation of thrombus and eventual gangrene.

Surgical Reduction of Congenital Dislocation of the Hip. Professor Oscar Scaglietti [38] briefly reviewed the results of treatment of 4,990 patients with congenital dislocation of the hip. Of these 3,628 (73 per cent.) were treated by closed reduction. Only 50 per cent. showed satisfactory results after a long-term follow-up. In 176 cases (4 per cent.) treated by open reduction, 25 per cent. had satisfactory results. In those treated by closed reduction a high percentage of failures was due to circulatory changes in the epiphysis, while in those treated by open reduction failures resulted from either redislocation or changes in the epiphysis and femoral neck secondary to operative trauma. As a result of these findings, the "frog-leg" position has been abandoned and the technique of operative reduction modified. The author's technique employed in sixty-three patients during the last eight years was illustrated by an excellent motion picture. Open reduction was employed when closed reduction failed and in patients in whom, for one reason or another, it was anticipated that closed reduction would be excessively traumatic. The principal obstacles to reduction were (1) a tight iliopsoas tendon and (2) intra-articular obstructions including a constricted capsular isthmus, pericephalic capsular insertion, hypertrophied ligamentum teres, and interposed limbus or adipose tissue. The author emphasized the gentleness of operative reduction made possible by a Smith-Petersen approach, Z-lengthening of the iliopsoas tendon, and careful removal of adipose tissue in the inferior half of the acetabulum.

Embryology of the Knee Joint. Dr. Anthony F. DePalma [39] reported the results of a study of the embryological development of the knee based on the examination of foetus ranging from ten to 238 millimeters, and of eighteen knees in infants and children obtained at amputation or autopsy. He concluded that the patella is not a sesamoid bone formed in response to functional stimuli, that the cruciate ligaments are differentiated from the mesenchymal cells of the intra-articular disc before the development of the capsule and synovial membrane, and are therefore not extrasynovial in origin, and that the synovial membrane arises from the superficial cells of the capsule and intra-articular structures, making its appearance after the formation of the cruciate ligaments, menisci, and capsule.

In discussion, Dr. Ernest Gardner [40] pointed out some of the complexities of such a study, including the necessity of examining a large number of specimens from all stages of foetal development and the recognition and avoidance of artifacts in the slides. In his opinion the synovial membrane developed considerably earlier than was indicated by Dr. DePalma. Moreover, the origin of the cruciate ligaments was not considered to be established. The majority of investigators consider that these arise from extrablastemic tissue or the synovial mesenchyma.

The Need for Basic Investigation in Orthopaedic Surgery. Dr. Francis M. McKeever [41]. The Presidential Address, presented to The American Academy of Orthopaedic Surgeons on January 27, 1953, is published in full in this issue of *The Journal*, beginning on page 285.

Internal Collateral Ligament Strain due to Occult Derangements of the Medial Meniscus. Dr. Frank B. Smith [42] and Dr. Harry C. Blair [43] operated upon thirty patients with symptoms of chronic tibial collateral ligament strain after the usual conservative measures had failed to give relief. Derangements of the medial meniscus were found in all cases even though the history and physical findings had not suggested such lesions. Characteristically, these patients complained of pain and tenderness aggravated by weight-bearing, especially with the knee flexed, and by any movement producing sudden external rotation of the tibia. There was no history of trauma or locking, and swelling, if noted at all, was mild. Examination revealed tenderness of the tibial collateral ligament and pain on lateral displacement or external rotation of the tibia on the femur with the knee flexed to 90 degrees. Infiltration of the tender area with novocain gave temporary complete relief. The universal operative finding was medial displacement of the central one third of the medial meniscus so that it impinged upon the overlying collateral ligament and produced irritation. This displacement was due to thickening of or apparent lengthening of the meniscus, to stretching of the anterior and posterior meniscal attachments, to tears of the meniscus of various sorts, and to multiple cysts of the meniscus. Adduction increased and abduction decreased the displacement in all but two knees. Complete displacement upward between the femur and the ligament occurred in four cases and downward between the tibia and the ligament in six cases. Meniscectomy invariably gave lasting relief.

In discussion, Dr. Allen F. Voshell [44] emphasized that numerous structures in the area of "the subtibial-collateral-ligament" may give these symptoms. He stressed the importance of making an accurate diagnosis and of giving conservative treatment a trial before arthrotomy is undertaken.

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DR. DON H. O'DONOGHUE [45] also offered a word of caution. Most patients with these symptoms are cured by conservative treatment. This should be given an adequate trial before surgery is resorted to.

Nylon Membrane Arthroplasty of the Knee in Chronic Arthritis. DR. JOHN G. KUHNS [46], DR. THEODORE A. POTTER [47], DR. ROBERT S. HORMELL [48], and DR. WILLIAM A. ELLISTON [49] reported their results from this operation in seventy cases which had been followed for six months or longer. The operative technique was essentially the same as that used in the past. The nylon sheet was secured to the femur by sutures or staples. In evaluating their results, they classified cases as good if they had 60 degrees of active flexion, adequate stability, and no pain. There were fifty-six cases of rheumatoid arthritis and eighteen with bony ankylosis. Of these, the results were good in forty-eight and unsatisfactory in eight, whereas in ten cases of osteo-arthritis, eight showed good results and two were unsatisfactory. In four patients with suppurative arthritis only two had good results. Among the unsatisfactory cases some improvement resulted from manipulation in six, quadriceps lengthening in three, and prolonged physical therapy in five. Painful motion occurred in ten patients. This was thought to result from loosening and the rolling up of one edge of the nylon. In six of these, relief followed removal of the nylon with good function. The remaining four were treated with some success, with physical therapy. Bony spurs developed around the joint margins in three cases and bony ankylosis occurred in two. There were three minor infections. No patient exhibited nylon sensitivity.

In discussion, DR. ROBERT A. KNIGHT [50] pointed out that final evaluation of the results must await the passage of time—at least five years.

DR. CARROLL B. LARSON [51] felt that the results of nylon arthroplasty represented some improvement over the similar operative technique using fascia. It was his opinion, however, that some method giving better joint congruity would have to be developed to improve significantly the results from knee arthroplasty.

WEDNESDAY, JANUARY 28, 1953

Syme Amputation Performed in Two Stages. COL. AUGUST W. SPITTLER [52], LT. COL. JOHN J. BRENNAN [53], and MAJOR JOHN W. PAYNE [54] reported thirty-six Syme amputations performed since 1944 according to a two-stage method, first described by Hulnick and evolved at Walter Reed Hospital.

Because of the two-stage technique many patients with feet irreparably damaged with infected and gangrenous wounds, even involving the calcaneus, may have the benefit of the Syme amputation instead of undergoing open amputation at the higher, less satisfactory levels. In the presence of open wounds, disarticulation at the ankle is followed by loose closure of the anterior and posterior flaps and by adequate drainage; this constitutes the first stage. When infection has ceased and sound healing has been obtained, the second stage is performed. This consists in converting the ankle disarticulation into a conventional Syme stump. The period of time between the two stages varied between three and thirty-six weeks, with an average of 9.4 weeks. Results have been gratifying; thirty of the thirty-four patients upon whom the method was employed wear their prosthesis a full day in the performance of their regular work. Four patients were able to return to duty in the Service; twenty-four are working as laborers. There have been three neuromata, each involving the superficial peroneal nerve. One patient required a thigh amputation for causalgia.

In discussing the two-stage procedure, DR. ATHA THOMAS [55] said it was widely recognized that the Syme stump, in selected cases, was valuable and that the method presented had apparently overcome some long-recognized contra-indications among which were infection, sloughing, and ulceration. He felt it should be employed only by those highly skilled in amputation surgery. Because he had seen tragic results from attempting the Syme amputation in the presence of peripheral vascular disease, he questioned the advisability of using it in the presence of this disease. In the case of most women, he felt it should not be used because of the unsightly prosthesis.

Report of the Committee on Scientific Investigation on the Preliminary Survey of Femoral-Head Prostheses. DR. CLAUDE N. LAMBERT [56] presented a preliminary analysis of the responses received to a questionnaire sent to the Academy membership. There were 587 replies indicating that 466 had used some form of prosthesis and 121 had not. Although several thousand operations had been done, the average period of follow-up was only ten months. A great variety of prostheses had been used, the Judet and Eicher being the most popular. The indications and contra-indications were not at all clearly defined. Of the indications

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cited, non-union, aseptic necrosis, and osteo-arthritis were the most common, but 214 answers gave fresh fracture as an indication. The contra-indications most commonly given were a young (up to forty to sixty-five years) patient, infection with tuberculosis, and rheumatoid arthritis. The list of operative complications was rather staggering, including dislocation, infection, fracture of the femur, pain, loose prosthesis, broken prosthesis, lump or prominence at the trochanter, absorption of the femoral neck, and sensitivity reaction to nylon. The Committee's impressions were that (1) the indications must be defined; (2) acrylic is being abandoned; (3) intramedullary types are gaining increasing favor; (4) complications are much too common; and (5) the Committee must continue this study for five to ten years before final evaluation of results will be possible.

In discussion, Dr. Duncan McKeever [57] emphasized the need for careful study of such problems from the viewpoint of the mechanical engineer to avoid disasters which in many instances are predictable. He reported experiments which indicated that the reaction to substances within the body is proportional to the surface area. A nylon sheet or block in the peritoneal cavity of an animal causes no reaction while the same amount of nylon ground into a powder produces a severe reaction.

The Patellar Advancement Operation. Dr. John P. Adams [58] and Dr. William M. Roberts [59] reviewed the results of bilateral patellar advancement operations in sixteen patients who were followed for an average of 6.5 years. They emphasized that, before this operation is undertaken, the patient must be a suitable candidate for surgical treatment. Furthermore, hip contractures, knee-flexion deformities, and equinus of the feet should be corrected surgically before the operation is performed. The quadriceps should have good to normal power and preferably be one grade stronger than the hamstrings, while the patella should be located several centimeters proximal to its normal position. Operative procedures such as obturator and sciatic neurectomies, obturator and hamstring tenotomies, and the like, may have to be done primarily to establish conditions satisfactory for the advancement procedure. The authors describe an operative technique in which the patellar tendon is divided and is secured in its new distal position beneath an osteoperiosteal flap by means of a screw and sutures; this minimizes the risk of disturbing the growth of the tibial epiphysis such as may occur when a block of bone is removed with the tendon. Postoperatively plaster immobilization is maintained for eight weeks and is followed by active exercise and weight-bearing as soon as knee extension can be maintained. The results were two excellent, three good, nine fair, and two failures. Poor selection of cases was responsible for the failures. In these the patients were unable to walk. Complications included recurrence of flexion deformity, genu recurvatum caused by growth disturbance in the tibia, and fracture of tibia.

In discussion, Dr. Fremont A. Chandler [60] re-emphasized the importance of proper selection of cases. In some instances contracture of the rectus femoris prevents proper advancement of the patella. Section of the rectus tendon will obviate this. He described a technique in which he plicated the tendon and held the patella in place with a loop of stainless-steel airplane cable.

Dr. Charles N. Pease [61] described another operative technique designed to assure no damage to the tibial epiphysis. The patella is held in its new position by means of two threaded wires, one of which is placed through it while the other is put through the tibia, both wires being incorporated in plaster. The tendon is shortened by being split longitudinally and the strips are woven back and forth through each other.

Femoral Shortening: An Evaluation of Intramedullary Nail Fixation. Dr. T. Campbell Thompson [62], Dr. Ramsay Straub[63], and Dr. Rolla D. Campbell, Jr.[64] reported their experience with eleven patients with femoral shortening by transverse osteotomy and intramedullary Küntscher nail fixation performed from 1948 through 1951. They contrasted the complications and outcome in this group with a comparable group of forty patients, whom they had treated between 1938 and 1951 at the Hospital for Special Surgery with femoral shortening by oblique osteotomy and screw fixation. In both groups the shortening amounted to one to three and one-quarter inches. There were only three secondary operations necessary in the forty patients treated by oblique osteotomy and screw fixation whereas twelve secondary operations were necessary in the group of eleven patients treated by Küntscher nails. One operative and four postoperative complications were encountered in the former group; there were seven operative complications and thirteen postoperative complications in the latter. More rapid and consistent bone healing occurred in the patients who had been treated by oblique osteotomy and screw fixation than in those treated by Küntscher nailing. The authors consider that the former method is far preferable and that the latter method should not be employed.

In discussing this report Dr. Lenox D. Baker [65] and Dr. David Grice [66] heartily endorsed the authors' conclusions.

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[62] 321 East 42nd Street, New York 17, N. Y.
[63] 321 East 42nd Street, New York 17, N. Y.
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The Use of Metal Staples and Accessory Bone-Chip Grafts in Foot Stabilization. Dr. Rufus H. Alldredge [67] and Dr. Daniel C. Riordan [68] described the use of metal staples and chip grafts in foot stabilizations. After careful trimming and fitting of bone surfaces from one to three staples were placed across the subtalar, calcaneocuboid, and, rarely, the talonavicular joints to obtain good stability. A plaster boot or merely a pressure dressing was used postoperatively followed by the application of a short cast before the patient's discharge. Total immobilization was for seven weeks to three months. The technique had been used in sixty-three operations, in twenty-two of which end-result studies had been made. In two patients, the staples had to be removed because of pain. The advantages claimed for this technique are greater comfort of the patient, early weight-bearing, and better results.

In his discussion of this paper Dr. Walter P. Blount [69] favored the procedure described and presented a method of fixation in which a Steinmann pin is inserted through the sole, transfixing the calcaneus, talus, and tibia. The pin is removed at the first change of cast. Dr. H. Relton McCarroll [70] considered the use of staples unnecessary in children. In his experience, proper alignment of the foot with the wound open is often difficult and, if staples are used, the position cannot be changed later.

Dr. Alldredge in closing emphasized that staples were not recommended in all foot stabilizations.

Report of the Committee for the Study of Preservation of Bone. Dr. Charles H. Frantz [71], Dr. Fred C. Reynolds[72], and Dr. Paul R. Lipscomb [73], chairman, analyzed 577 replies to questionnaires sent to the Academy membership during the year 1951. Of these, 200 members did and 377 did not use preserved bone. A total of 3,104 cases in which bank bone had been used were reported. There were eighty-seven infections (an incidence of 5 per cent.) with the use of merthiolate-preserved bone and an incidence of infection of 2 per cent. with bone preserved by freezing or some other technique. In instances in which the bone transplant had been cultured, the incidence of infection was 2 per cent. as compared with 4 per cent. in those in which no cultures had been made. The method of preservation did not appear to influence the incidence of aseptic absorption of the graft. The results of grafting procedures were difficult to evaluate for various reasons. In spine fusions the reported failures were only 7 per cent. with over-all good results in 68 per cent. In major nonunions the failure rate was 14.4 per cent. with over-all good results in 71 per cent. The incidence of failure was 13 per cent. with merthiolate-preserved bone and 9 per cent. with the others. The Committee concluded that bank bone gives consistently poorer results than autogenous bone, but that it still has its place in selected cases. The use of frozen bone results in fewer complications and gives better results than that of bone preserved with merthiolate.

Thursday, January 29, 1953

The Use of Hyaluronidase in Clinical Orthopaedics. Dr. William MacAusland, Jr.[74], Dr. John J. Gartland [75], and Dr. Halford Hallock [76] reported gratifying results from the injection of the enzyme hyaluronidase (the spreading factor of Duram-Reynals) into hematoma, regions of ligamentous sprain, the site of recent fracture, into the hemarthrotic joints of hemophiliacs, into regions of threatened Volkmann's contracture, and into recently arthrotomized joints. One thousand to 1,500 TR units * of the enzyme are injected along with one to eight cubic centimeters of 1 per cent. procaine into the site of the fluid accumulation. To augment the action of the enzyme a pressure bandage is applied. Not only is excess fluid dispersed in the more common conditions cited but real hope may be not too far removed for the seemingly hopeless hemophiliac. Dispersion of fluid results from the depolymerization of hyaluronic acid, the main constituent of the intercellular ground substance.

In discussion Dr. J. A. Key [77] asked if the enzyme would lessen swelling in Colles' fracture and if it would check bleeding in the hemophiliac.

Dr. Lee C. Schlesinger [78] had had favorable experience with the enzyme and asked about its effect in the presence of infection. Dr. MacAusland replied that he had found hyaluronidase helpful in Colles' fracture; it would not, however, arrest hemorrhage. He had not used it in infections.

The Use of Iproniazid in the Treatment of Bone and Joint Tuberculosis. Dr. David M. Bosworth [79], Dr.

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[72] 4952 Maryland Avenue, St. Louis 8, Missouri
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[75] New York, N. Y.
[76] 180 Fort Washington Avenue, New York 32, N. Y.
[77] 4952 Maryland Avenue, St. Louis 8, Missouri
[78] 3439 Prytania Street, New Orleans, Louisiana
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* A TR (turbidity reduction) unit is that quantity of the enzyme which will reduce turbidity in thirty minutes from that corresponding to 200 gammas of sodium hyaluronate to 100 gammas.

Howard A. Wright [80], and Dr. J. William Fielding [81] reported their experiences with iproniazid in the treatment of sixty-six patients with tuberculosis of bones and joints, among whom there were ninety-eight tuberculous lesions. Forty-four of these lesions healed, thirty-seven were improved, and sixteen were unimproved. The period of treatment extended from November 1951 to January 1, 1953. Their report is considered dependable by the authors with respect to dosage, improvement, toxicity, laboratory findings, operative complications, reaction to anaesthesia, and preoperative medication. In other respects — such as the question of permanency of recovery; studies of tissue cultures; nitrogen, calcium, and phosphorus balances; bone-ash determinations; roentgen changes; use with other drugs; vitamin treatment; dietary changes; control of withdrawal of medication; the development of late and still unrecognized toxicities — new findings may arise and new conclusions may have to be drawn. Five patients died. Fifty-seven gained weight. Fifty-four had satisfactory temperature records. Four patients of thirty-four with pain failed to gain relief of their pain.

Of the sinuses in thirty-eight patients, all sinuses healed in sixteen; the sinuses in thirteen closed; five were markedly improved. In four, the sinuses did not heal or show evidence of healing.

As regards the bacteriostatic action of the drug on the *Mycobacterium tuberculosis* there were thirty-one patients with proved open lesions. Twenty-seven of these either healed so that further culturing was no longer possible or all cultures were negative throughout the period of medication; three had only a single positive culture among many that were negative; one had an occasional positive culture.

Streptomycin had been given prior to iproniazid therapy in fifty-three of the sixty-six patients but beneficial effects were present in only five; in the other forty-eight the benefit had ceased or the patient's condition was actually deteriorating. Where patients had been improving satisfactorily on streptomycin, iproniazid was withheld. Iproniazid was given as the primary therapy in only thirteen of the sixty-six patients.

Dosage had been determined strictly according to body weight accurately determined. The drug was begun at four milligrams per kilogram of body weight. If severe hypertoxicity or clonus supervened, the dose was dropped to two milligrams per kilogram and then gradually was raised to between three and four milligrams per kilogram. Doses under three milligrams were much less effective.

The average number of days of treatment was 140.1, the longest was fourteen months, the shortest twenty-eight days.

Withdrawal of the drug over a period of several days is advisable; sudden withdrawal is to be avoided.

Toxic symptoms included dizziness, tremor, positive Babinski reflex, hypertonic reflexes, clonus, euphoria, drowsiness, headache, tinnitus, psychosis, coma, mouth dryness, diaphoresis, visual accommodation weakness, urinary hesitancy, obstipation, impotence, flushing, twitching, and paraesthesia.

The authors felt that hospitalization was advisable during the period of iproniazid administration.

Laboratory tests had been carried out extensively. Findings were uniformly within normal limits except that there was a drop in the platelet count in thirteen of twenty-nine patients. In one patient there was a drop in the eosinophil count, and in fifty-two patients liver-function tests showed evidence of damage in nine. Later, regardless of iproniazid there had been a return to normal liver function, according to the tests.

Anaesthesia and other standard preoperative drug therapy seemed to be unaffected by the iproniazid. Twenty-three open operations of major proportions were performed on patients in this series—all without complication.

Iproniazid seemed to have had no effect on tissue cultures, capillary proliferation, or epithelial stimulation. In high concentrations inhibition was observed. Generalized osseous decalcification seemed to occur after several weeks of medication.

In their discussion of the foregoing paper, Dr. Edward T. Evans [82] and Dr. Frederic C. Bost [83] warmly endorsed the thoroughgoing clinical studies of Dr. Bosworth and his co-workers, and agreed with him in cautioning against too precipitate and indiscriminate use of a drug so potent and so potentially toxic. The question was asked if the drug had been used locally. Dr. Bosworth advised against this since the dosage could not be accurately controlled if the drug was given in that way. Its effectiveness was doubted and its toxicity was feared if it was so administered. Dr. Bosworth advised against giving the drug at present in conjunction with streptomycin.

The Surgical Treatment of Spasmodic Torticollis. Dr. H. T. Wycis [84] and Dr. John R. Moore [85], impressed by the small proportion of cases of this condition cured by psychiatric therapy and by Foerster's explanation of the painful persistent or intermittent muscular contractions occurring "on the basis of an intermittent flow of thalamic impulses following lesions of the corpus striatum", have turned to surgery as offering the best treatment at present available. The operation chosen consisted in the intradural section of both spinal accessory nerves and the anterior roots of the first three cervical nerves, bilaterally, together with unilateral intradural section of the anterior division of one of the fourth cervical nerves. The method had been

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evaluated on the basis of outcome in nine patients, all of whom were dramatically relieved of all contractures, except one patient who retained a slight residual spasm unilaterally. Following operation the use of a brace has not been necessary, although cervical motor paralysis is very extensive at first, making necessary a conscious balancing by the patient. The patients have been followed for one to seven years.

Treatment of Deformities of Pott's Fracture. Dr. Rudolph S. Reich [86] and Dr. Norman J. Rosenberg [87] discussed the treatment of Pott's fractures. In acute cases not only must the valgus deformity and widening of the ankle mortise be corrected but also union of the medial malleolus and restoration of the deltoid ligament be assured. Usually manipulation and immobilization in a plaster cast is adequate. If frequent x-rays reveal inadequate reduction or loss of position, open reduction and internal fixation are necessary. Where initial treatment has not been successful, open reduction can still be carried out successfully after a considerable period, provided that osteo-arthritic changes, malunion of a large posterior fragment of the tibial articular surface, or avascular necrosis of the talus is not present. The operative technique described included exposure through medial and lateral longitudinal incisions, a long oblique osteotomy of the fibula, manipulative correction of the valgus deformity in which a Thomas wrench is used if need be, restoration of the mortise by fixing the distal fibular fragment to the tibia by screw or bolt, fixation of the medial malleolus with bone graft and a Zuelzer plate, as well as the repair of the deltoid ligament when ruptured. Postoperative immobilization without weight-bearing was continued for three months. Four patients so treated with good functional results were reported.

In discussion Dr. Joseph S. Barr [88] stressed that the procedure of late open reduction should be attempted only if the articular surfaces were inspected and were found to be in satisfactory condition at the time of operation. Otherwise, ankle fusion should be done, for this operation gives relief from pain and excellent function, except in climbing stairs or walking on rough ground. Dr. Carlo S. Scuderi [89] emphasized the importance of early open reduction of ankle fractures where closed reduction is not perfect. At this time, hairline reduction is possible and osteoporosis has not developed to impair fixation. In his opinion, ankle fusion causes considerable disability and should be used as a last resort only.

The following are the brief summaries of the thirty-two scientific exhibits presented at this meeting:

Acetabulo-Arthroplasty. Dr. Roger Anderson and Dr. Ivan Loughlen [1] showed a replacement prosthesis of either acrylic or stainless steel with the surgical technique and instruments for its use. This prosthesis is of one size with a round metal stem which is cut off on the trochanter side to fit the patient. It may be used to fit over a special plate, if desired. The acetabulum is revised to accommodate the prosthetic head.

Bone and Joint Tuberculosis. Treatment with Iproniazid. Dr. David Bosworth, Dr. Howard Wright, and Dr. Joseph Fielding [2] presented an excellent exhibit on their clinical experience with a new chemical for combating tuberculosis, which has been used primarily in patients who have not done well on streptomycin or who had overwhelming infections. Many in desperate condition when the treatment was started showed gratifying improvement.

In the use of this chemical there is such a narrow margin of safety that the dose must be accurately administered. The optimum dose is four milligrams per kilogram of body weight (by actual measurement) per day. More than this may produce toxic signs and less than this does not give the desired result.

The toxic signs are mouth dryness, weakness of visual accommodation, hesitancy, dizziness, tremor, euphoria, paraesthesia, hyperactivity, hyperactive reflexes, clonus, and psychosis. Constant supervision of the patient is necessary to detect these changes early. Withdrawal must be gradual over a one-to-three week period.

Sixty-six patients have been treated to date with sixteen failures. However, many of them would have died under other methods. This is a preliminary report and further experience over a longer period of time is needed to evaluate the drug fully.

Bone Grafts: Experimental Study. Dr. Crawford J. Campbell and Dr. Thomas Brower [3].

This material was attractively presented with good slides showing the results of various types of bone grafts in animals. The results were similar to other exhibits of this nature and were subject to the same limitations.

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[2] Sea View Hospital, Staten Island, New York, and St. Luke's Hospital, New York, N. Y.
[3] Albany Medical College, Albany, New York

Plastic Draping in Orthopaedic Surgery. Dr. Bart Cole, Dr. Killian Fritsch, and Dr. L. J. Hill [4].

A demonstration of the use of prepared sterile plastic drapes was presented. This material would be useful in a disaster area if it were stock-piled for that purpose.

Diagnostic Problems. The American Academy of Orthopaedic Surgeons, Committee on Pathology.

This was a well presented study of twelve cases giving the history, physical and laboratory findings, and the x-ray and microscopic examinations. In each case it was possible to make the diagnosis from these examinations. However, the cases were not easy. It is doubtful that many were able to diagnose them all. It is felt that this type of exhibit should be encouraged. Perhaps it would stimulate more careful study if the members were required to list their diagnoses and deposit them in a box, a prize being offered to the ones obtaining the best score.

The Oregon Bone Tumor Registry. Dr. George W. Cottrell and Dr. Sheldon Jacobson [5].

The establishment of a state bone tumor registry at a medical center under the supervision of a competent pathologist would, they felt, give a better service to that area, as well as help to accumulate a series of valuable pathological material. In this exhibit the specimens could not be adequately studied because the microscopic slides were of too low a magnification.

The Arthrotomized Knee: An End-Result Study. Dr. Sidney N. Eichenholtz and Dr. Arthur S. Abramson [6].

This exhibit re-emphasized the value of restoration of quadriceps power in the postoperative management of knees subjected to surgery. A demonstration of a method of exercise for this purpose was presented.

Further Studies on Horizontal Lateral Roentgenography of the Hip in Children. Dr. Herbert C. Fett, Dr. Donald J. Magilligan, Dr. James C. Barnett, and Dr. Herbert C. Fett, Jr.[7]

This exhibit demonstrates the authors' technique of measuring the degree of anteversion of the neck of the femur by x-ray in cases of congenital dislocation of the hip.

Mechanism of Nerve-Root Compression by the Posterior Elements in Spondylolisthesis and Spina Bifida Occulta of the First Sacral Segment. Dr. Gerald G. Gill, Dr. Hugh L. White, and Dr. John G. Manning [8].

The authors present a new concept of the mechanism of production of low-back and sciatic pain in cases of spondylolisthesis and spina bifida occulta. In cases of the former they feel that a fibrocartilaginous mass at the area of pseudarthrosis of the pedicle produces nerve-root compression. Relief is obtained by removal of this mass as well as of the posterior element and the ligamentum flavum without spine fusion. In cases of spine bifida occulta of the first sacral segment, pain may be produced on extension of the back by pressure on the cauda equina caused by the spinous process of the vertebra above. This spinous process may be fused with a process of the remnant of the spinous process of the bifid vertebra below. This produces a long caudal process which causes pressure on backward bending.

Again the condition is relieved by removal of this offending element. The number of patients so treated is small and the period of follow-up short. Further study is necessary to determine whether or not this concept is correct, but experience so far has been confirmatory and results have been good.

Use of Intermittent Traction in the Cervical Spine Syndrome. Dr. Jesse B. Griffith [9].

Dr. Griffith demonstrated an ingenious machine to apply traction of various strengths and duration to the cervical spine. Very strong traction may be used if applied at the rate of four pulls per minute, a method of application which he claims is more effective than continuous lesser traction.

Biomechanics and Photo-Elastic Stress and Strain Analysis in Arthroplasty of the Hip. Dr. Edward J. Haboush [10].

By means of transparent plastic models of the upper end of the femur Dr. Haboush demonstrated the points of stress when pressure was applied to the head. These were determined by the variable alteration in polarized light. The stress points as demonstrated seemed to be in line with our concepts. He also demonstrated a prosthesis consisting of a femoral head and an acetabular socket, both of which were made of Vitallium.

Poliomyelitis. Surgical Rehabilitation of the Calcaneous Foot and Apparatus for the Upper Extremity. Dr. C. E. Irwin [11]. Operative technique of transposition of the posterior tibial and peroneal tendons to the

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[7] St. Charles Hospital, Brooklyn, N. Y.
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[10] New York, N. Y.
[11] Georgia Warm Springs Foundation, Warm Springs, Georgia

calcaneus and postoperative follow-up were shown. Various splints were also demonstrated for exercise of the upper extremity.

Early and Late Treatment for Subcapital and Transcervical Neck Fractures of the Hip. Dr. Eugene L. Jewett, Dr. Fred H. Albee, Jr., and Dr. F. DeWitt Stanford [12].

The various uses of the Jewett nail were illustrated. The exhibitors recommend its use for neck fractures as well as for trochanteric fractures, particularly as the nail may be used with a prosthetic head fitted over its end, should aseptic necrosis or non-union occur, requiring reconstruction. In some instances the nail need not be removed. The practical value of this feature for trochanteric fractures as well as for neck fractures seems doubtful.

Fractures of the Forearm. Dr. William Johnson [13] presented methods of management of forearm fractures with external skeletal fixation following reduction as well as with intramedullary fixation.

Management of Hemophilic Arthritis. Dr. Henry H. Jordan and Dr. Francis B. Roth [14].

An interesting and large (forty-five cases) series of hemophiliac patients was presented. The advantages of conservative measures were pointed out which include correction of deformity by cast and brace and the control of hemorrhage by whole-blood transfusions.

Easter Seal Library Services. Mr. Lawrence J. Linck [15].

A large and seemingly complete library collection is maintained and made available by The National Society for Crippled Children and Adults.

Functional Fixation of Fractures. Dr. W. K. Massie and Dr. O. B. Murphy [16].

The authors make a plea for adequate internal fixation of fractures where open reduction is indicated so that the use of external fixation may be eliminated or markedly lessened. They show that in patients in whom intramedullary fixation does not prevent rotation a plate should be added. In this manner early active use of the injured extremity may be made possible.

Complications following Replacement Arthroplasty of the Hip. Dr. Howard A. Mendelsohn and Dr. Seymour L. Alban [17].

A report of forty patients in whom forty-five replacement prostheses had been used in hip reconstruction was presented. Of these cases 57 per cent. had some form of complication. Infection, however, was not a major problem. This exhibit demonstrated that there is much to be learned regarding the use of prostheses for the upper end of the femur.

Scapulocostal Syndrome. Dr. Arthur A. Michele and Dr. Frederick J. Krueger [18].

These exhibitors listed most of the conditions which may cause pain and tenderness (trigger-points) about the shoulder girdle under the heading of scapulocostal syndrome. These they treated by injection of the tender areas with novocain. Good results were reported.

Substitution of the Talus Head for the Talus Body. Avulsion Fracture of the Talus Bone. Dr. Earl D. McBride and Dr. Russell D. Harris [19].

Six cases of fracture or fracture-dislocation of the talus were demonstrated in which the body of the talus was removed. The ankle joint is reconstructed by the substitution of the head of the talus in such a way that the articular cartilage of the head is in contact with the distal end of the tibia. The head is fixed to the calcaneus with one metal screw. Good results were reported even though the head of the talus underwent aseptic necrosis.

Regional Stress Angiography of the Hip. Dr. Jesse T. Nicholson, Dr. Harvey P. Kopell, and Dr. Frank A. Mattei [20].

This was a study of the effect of the "frog-leg" position as used in the treatment of congenital dislocation of the hip on the circulation about the hip. Using fresh autopsy material from infants, the authors injected the arteries with radiopaque material. They found that in the "frog-leg" position there was interference with filling of the medial and lateral circumflex arteries; this filling defect can be corrected by an adductor tenot-

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[14] The Hemophilia Foundation, Inc., New York, N. Y.
[15] The National Society for Crippled Children and Adults, Inc., Chicago, Illinois
[16] Lexington, Kentucky
[17] Wadsworth Hospital, Veterans Administration Center, Los Angeles, California
[18] New York Medical College, New York, N. Y., and the United States Public Health Hospital, Staten Island, New York
[19] Oklahoma University School of Medicine, Oklahoma City, Oklahoma
[20] Children's Hospital, Philadelphia, Pennsylvania

omy. The question was raised by some of the effect on the circulation of the position of abduction and internal rotation both before and after derotational osteotomy, as well as in the case of an untreated congenital dislocation of the hip.

Retention of the Foetal Position. Dr. Sylvester J. O'Connor, and Dr. Carl E. Badgley [21].

This was a well presented exhibit showing postnatal effects of the foetal position on the extremities of the infant. The retained position may need correction.

King-Sized X-Rays. Dr. R. Beverly Raney, Dr. Ernest H. Wood, Dr. C. A. Bream, and Dr. James G. McClure [22].

This exhibit demonstrated a method of obtaining large and detailed x-ray films which show bone detail much more clearly than the conventional x-rays. It should be useful in bringing out obscure lesions of bone. The technique is simple and not expensive after a special tube with a small focal point has been obtained.

Application of Various Types of Body Casts. Dr. J. C. Risser, Dr. W. A. Craig, Dr. C. H. Lauder, Jr. and Dr. Donald Norquist [23].

The authors demonstrated by actual application their methods of applying and using three types of body casts. For these, they used their special frame. This device certainly works well in their hands and should improve the general use of body casts.

Experiences with the Bone Bank. Dr. Norman J. Rosenberg and Dr. George W. Bennett [24].

This exhibit showed various uses of bank bone. According to the cases reported, this form of graft has worked out well in their experiences.

Two-Stage Syme's Amputation. Col. August W. Spittler [25].

This was an impressive demonstration of what can be done to conserve the length of the extremity in badly damaged feet by the use of sound principles and antibiotics. Some very satisfactory Syme stumps had been obtained in cases that would ordinarily have been subjected to below-the-knee amputations. A new light plastic prosthesis to be used with a Syme stump was also exhibited.

Oblique X-Ray Studies of Hip Dislocation. Dr. Clifford C. Taylor and Dr. Carl D. Martz [26].

The exhibit consisted of a demonstration of a method of obtaining oblique x-rays of the pelvis at a 45-degree angle in cases of congenital dislocation of the hip. By this method it can be shown whether the dislocation is anterior or posterior.

Gross Osteopathology of Arthritis. Dr. William J. Tobin, Dr. T. D. Stewart, and Dr. Robert C. Hawkins [27].

A collection of arthritic specimens was presented which included material showing arthritic changes in animals.

Equipment Aids Developed in the Orthopaedic Section. Maxwell Air Force Base Hospital [28].

This consisted of a demonstration of an especially built table to be used in the nailing of fractured hips or in other hip surgery in which x-ray examinations are required. A hydraulic exercising machine was also shown.

Management of Poliomyelitic Patients with Respiratory Difficulty. Dr. Hart E. Van Riper [29].

A rather complete array of methods was demonstrated of meeting respiratory needs in paralytic poliomyelitis. Various types and sizes of respirators were shown, as well as tilt boards, positive suction apparatus, and tracheotomy sets.

Experimental Studies with Self-Curing Acrylic as Applied to Orthopaedic Surgery. Dr. Leon L. Wiltse and Dr. Richard E. Hall [30].

This was an interesting demonstration of self-polymerizing plastics which can be molded to desired shapes or configurations at the operating table and which become quite hard at body temperatures. Animal

[21] Ann Arbor, Michigan
[22] University of North Carolina School of Medicine, Chapel Hill, North Carolina
[23] Los Angeles Orthopaedic Hospital, Los Angeles, California
[24] Veterans Administration—Mt. Sinai Hospitals, Western Reserve University, Cleveland, Ohio
[25] Walter Reed Army Hospital, Washington, D. C.
[26] St. Vincent's Hospital, Indianapolis, Indiana
[27] Georgetown University Medical Center and Smithsonian Institute, Washington, D. C.
[28] Maxwell Air Force Base, Alabama
[29] National Foundation for Infantile Paralysis, New York, N. Y.
[30] Long Beach Veterans Administration Hospital, Long Beach, California

experimentation has suggested that these substances gave promise of usefulness in the fields of bone replacement and internal fixation. The plastics seem to be fairly inert in the tissues and if so, should have many uses.

An excellent selection of films was presented on the Audio-Visual Program under the chairmanship of Dr. Lee Ramsay Straub. The program was as follows:

SATURDAY, JANUARY 24

Afternoon Session

Transtrochanteric Osteotomy of the Femur for Non-Union.
Stanley S. Haft, M.D., Los Angeles, California.
Technique of Horizontal Lateral Roentgenography of the Hip in Children.
Herbert C. Fett, Jr., M.D., Herbert C. Fett, M.D., Donald J. Magilligan, M.D., and James C. Barnett, M.D., Brooklyn, New York.
Reconstruction of a Severely Injured Forearm.
R. A. Murray, M.D., Temple, Texas.
The Magnuson Operation for Habitual Shoulder Dislocation.
T. A. Lynn, M.D., Los Angeles, California.
Surgical Approaches to the Hip Joint.
LeRoy Abbott, M.D., San Francisco, California.
Home Rehabilitation of Severe Post-Poliomyelitic Paralysis.
Robert O. Whitson, M.D., Baytown, Texas.
Plastic Interposition in Knee Reconstruction.
Duncan McKeever, M.D., Houston, Texas and F. Garrett Pipkin, M.D., Kansas City, Missouri.

SUNDAY, JANUARY 25

Afternoon Session

Congenital Torticollis, Chandler Excision of Sternocleidomastoid.
Joseph H. Reino, M.D., Bethlehem, Pennsylvania.
The Mortised Bone Block Facet Fusion Operation for the Lumbar Spine.
Earl D. McBride, M.D., Oklahoma City, Oklahoma.
Flexor-Tendon Grafting in the Hand.
Walter Graham, M.D., Santa Barbara, California.

TUESDAY, JANUARY 27

Afternoon Session

Steindler Tendon Transplantation at the Elbow.
Leo Mayer, M.D., New York, N. Y.
Medullary Nailing for Fractures of the Tibia.
J. O. Lottes, M.D., L. J. Hill, M.D., S. M. Leydig, M.D., and J. A. Key, M.D., St. Louis, Missouri.
Primary Vitallium Mold Arthroplasty for Fracture Dislocation of the Hip.
Paul R. Lipscomb, M.D., Rochester, Minnesota.
Upper Extremity Prosthetics.
Veterans Administration, Augustus Thorndike, M.D., Acting Director, Prosthetic and Sensory Aids Service in Cooperation with the Staff of the Artificial Limbs Project, Department of Engineering, University of California at Los Angeles.

WEDNESDAY, JANUARY 28

Afternoon Session

Iliotibial Band Syndrome.
C. E. Irwin, M.D., Warm Springs, Georgia.
The Mechanism of Nerve-Root Compression in Spondylolisthesis as Revealed at Surgery.
Gerald G. Gill, M.D., San Francisco, California.
The Story of Lucy.
Carl A. Maxwell, M.D., West Orange, New Jersey.

An exceptional program of Instructional Courses was arranged by Dr. Charles N. Pease, Chairman of the Instructional Course Committee. The Instructional Course dinner, held on Monday evening, January 26, was again highlighted by the "Panel of Experts".

The first Executive Session was held on Sunday afternoon, January 25. The following new members were inducted:

Nick J. Accardo, M.D., New Orleans, Louisiana
Albert B. Accettola, M.D., Staten Island, New York
John Henry Akles, M.D., Los Angeles, California

Cameron S. Allen, M.D., Vancouver, British Columbia, Canada
Martin E. Anderson, Jr., M.D., Denver, Colorado
Robert F. Anderson, M.D., Salem, Oregon
William Argo, M.D., Fresno, California
Leon Joseph Armalavage, M.D., Gary, Indiana
John D. Ashby, M.D., Battle Creek, Michigan
Stanley M. Bach, M.D., Omaha, Nebraska
Walter L. Bailey, M.D., Wilmington, Delaware
Edward W. Bank, M.D., Enid, Oklahoma
Harry E. Barnett, M.D., Chicago, Illinois
Chester K. Barta, M.D., San Diego, California
Gerhard H. Bauer, M.D., Ann Arbor, Michigan
Edward E. Bauman, M.D., Warren, Ohio
John C. Becker, M.D., Reno, Nevada
John Joseph Beer, M.D., St. Paul, Minnesota
Donald F. Bellamy, M.D., Oakland, California
Harry Edward Beller, M.D., Miami, Florida
Theodore J. Bender, Jr., M.D., Mobile, Alabama
Alfred R. Berkeley, Jr., M.D., Charlotte, North Carolina
Isabel Bittinger, M.D., Winston-Salem, North Carolina
Michael Bonfiglio, M.D., Iowa City, Iowa
Maccabae Boorstein, M.D., Flushing, New York
Robert F. Botkin, M.D., Pittsburgh, Pennsylvania
Walter L. Butterfield, Jr., M.D., Hartford, Connecticut
Lynn Randall Callin, M.D., Rochester, New York
Anthony L. Camarda, M.D., Bridgeport, Connecticut
Thomas Campanella, M.D., Baton Rouge, Louisiana
Edmond Chadwick Campbell, M.D., Lake Charles, Louisiana
William S. Cappeller, M.D., San Francisco, California
C. Sanford Carlson, M.D., Knoxville, Tennessee
James C. Carmack, M.D., San Bernardino, California
Earnest B. Carpenter, M.D., Richmond, Virginia
Robert Ernst Carroll, M.D., New York, N. Y.
John Marshall Carter, M.D., Huntington, West Virginia
S. Ward Casscells, M.D., Wilmington, Delaware
Robert H. Cassidy, M.D., Milwaukee, Wisconsin
Haynes Burke Cates, M.D., Wilmington, Delaware
Morgan R. Colbert, M.D., Louisville, Kentucky
John Fletcher Comer, M.D., Birmingham, Alabama
Weston Carrier Cook, M.D., Columbia, South Carolina
Daniel G. Costigan, M.D., Louisville, Kentucky
George W. Cottrell, M.D., Portland, Oregon
Ausmon E. Culmer, Jr., M.D., Grand Forks, North Dakota
John Nicol Daly, M.D., Rochester, New York
John James Davies, M.D., Moline, Illinois
Joseph Robert Deitz, M.D., Trenton, New Jersey
Cornell Leonard Dereng, M.D., Chicago, Illinois
Fred Ennis Dexter, M.D., Albany, New York
Richard B. Donaldson, M.D., Chattanooga, Tennessee
Michael M. Donovan, M.D., Houston, Texas
F. Paul Duffy, M.D., Cincinnati, Ohio
Peter J. Dulligan, Jr., M.D., Brooklyn, New York
William R. Eaton, M.D., Pittsburgh, Pennsylvania
Norman Egel, M.D., Rochester, New York
Sidney N. Eichenholtz, M.D., Yonkers, New York
Robert B. Elliott, M.D., Houston, Texas
Herman C. Epstein, M.D., Los Angeles, California
William B. Ferguson, M.D., Lafayette, Indiana
Edward Joseph Ferrarone, M.D., Springfield, Massachusetts
Herbert C. Fett, Jr., M.D., Brooklyn, New York
John C. Feuling, M.D., Duluth, Minnesota
John Florence, M.D., Oklahoma City, Oklahoma

Lee Thomas Ford, Jr., M.D., St. Louis, Missouri
Samuel H. Frarerman, M.D., Chicago, Illinois
Elmer F. Franseen, M.D., Springfield, Massachusetts
Zachary Bert Friedenberg, M.D., Philadelphia, Pennsylvania
Calvin Edward Gantenbein, M.D., Portland, Oregon
Isaac L. George, M.D., Baton Rouge, Louisiana
Joseph Howland Gill, M.D., Vancouver, Washington
Benjamin S. Golub, M.D., New York, N. Y.
Marvin C. Goodman, M.D., Lancaster, Pennsylvania
Homer Graham, M.D., Burbank, California
Alan W. Gray, M.D., Los Angeles, California
Marvin C. Green, M.D., Toledo, Ohio
Lawrence L. Griffin, M.D., Austin, Texas
Joseph F. Gross, M.D., Omaha, Nebraska
John F. Grube, M.D., Manhattan Beach, California
Walter Andrew Gunther, M.D., Troy, New York
Herbert A. Hamel, M.D., Kansas City, Missouri
Russell D. Harris, M.D., Oklahoma City, Oklahoma
Arthur Raymond Hartwig, M.D., San Francisco, California
Mark R. Harwood, M.D., Syracuse, New York
Elwood N. Hathaway, M.D., Marysville, California
Robert C. Hawkins, II, M.D., Toledo, Ohio
Carl L. Holm, M.D., Salem, Oregon
Robert V. Holman, M.D., Brooklyn, New York
William W. Howe, Jr., M.D., Rochester, New York
Bernard J. Hubenet, M.D., Rutland, Vermont
John Marshall Hundley, M.D., Little Rock, Arkansas
John Cyrus Ivins, M.D., Rochester, Minnesota
Otis E. James, Jr., Kansas City, Missouri
Walter F. Jennings, M.D., Hartford, Connecticut
Claran H. Jesse, M.D., Ardmore, Oklahoma
Porteous E. Johnson, M.D., Muskogee, Oklahoma
Asa C. Jones, M.D., Lima, Ohio
Richard H. Jones, M.D., Minneapolis, Minnesota
Saul R. Kaplan, M.D., Philadelphia, Pennsylvania
Jacob Feuer Katz, M.D., New York, N. Y.
Daniel O. Kayfetz, M.D., Pittsburg, California
Edward F. Kickham, M.D., Saginaw, Michigan
F. Bruce Kimball, M.D., San Diego, California
Robert M. Kimball, M.D., San Diego, California
Joe W. King, M.D., Houston, Texas
Robert J. W. Kinzel, M.D., Indianapolis, Indiana
William A. Klein, M.D., Duluth, Minnesota
William Ewart Knight, M.D., Fort Smith, Arkansas
George L. Kraft, M.D., North Hollywood, California
William Kruger, M.D., Newark, New Jersey
Raymond F. Kuhlmann, M.D., Burlington, Vermont
Morris Lang, M.D., Kankakee, Illinois
Joseph Thurston Leach, M.D., Columbus, Ohio
Moses Leeb, M.D., Cleveland, Ohio
Milton I. Lenobel, M.D., St. Louis, Missouri
Morton H. Leonard, M.D., El Paso, Texas
Thomas T. Lewis, M.D., San Mateo, California
Cuyler P. Lipscomb, M.D., Fort Worth, Texas
Donald W. Lyddon, M.D., Rockford, Illinois
Ford J. Macpherson, M.D., Shreveport, Louisiana
Herbert K. Magill, M.D., Brookline, Massachusetts
Samuel R. Manelis, M.D., Fall River, Massachusetts
William K. Massie, M.D., Lexington, Kentucky
Carl A. Maxwell, M.D., Morristown, New Jersey
Donald P. McDonnell, M.D., Whittier, California
John J. McGillicuddy, M.D., Boston, Massachusetts

Sidney R. McPherson, M.D., Hartford, Connecticut
George G. McShatko, M.D., West Point, New York
Robert Brown Mearns, M.D., Sacramento, California
Harry Merliss, M.D., Hackensack, New Jersey
John F. Merritt, M.D., Santa Barbara, California
Paul W. Meyer, M.D., Kansas City, Missouri
George R. Miller, M.D., Gastonia, North Carolina
Walter R. Miller, M.D., San Francisco, California
Paul R. Milligan, M.D., Salt Lake City, Utah
Jack W. Millis, M.D., Toledo, Ohio.
Joseph J. Mira, M.D., Alton, Illinois
Howard E. Mitchell, M.D., Lincoln, Nebraska
James M. Muckley, M.D., Canton, Ohio
Owen B. Murphy, M.D., Lexington, Kentucky
Robert Delevan Mussey, M.D., Urbana, Illinois
John W. Naame, M.D., Atlantic City, New Jersey
Elwin G. Neal, M.D., Miami Shores, Florida
William Nelson, M.D., Denver, Colorado
Anthony V. Nevulis, M.D., New Britain, Connecticut
William H. Newman, M.D., New Orleans, Louisiana
Werner Nobel, M.D., Brooklyn, New York
Eugene Jorgen Nordby, M.D., Madison, Wisconsin
Theodore Norley, M.D., West Palm Beach, Florida
William H. Oetting, Jr., M.D., New Rochelle, New York
Laszlo Ormandy, M.D., Washington, D. C.
Caesar F. Orofino, M.D., Memphis, Tennessee
Frank F. Parrish, M.D., Houston, Texas
Jack Paschall, Jr., M.D., Pasadena, California
Frank Porter Patterson, M.D., Vancouver, British Columbia, Canada
Frank F. Paxton, M.D., Glendale, California
Aaron W. Perlman, M.D., Cincinnati, Ohio
W. Houston Price, M.D., Chattanooga, Tennessee
Ira H. Rapp, M.D., Charlotte, North Carolina
Eber Resnick, M.D., Syracuse, New York
Robert M. Richman, M.D., New York, N. Y.
Edwin G. Robinson, M.D., Portland, Oregon
Robert A. Robinson, M.D., Rochester, New York
Ralph G. Rohner, M.D., New York, N. Y.
William C. Roland, M.D., Newport, Rhode Island
Robert L. Rosen, M.D., Mount Vernon, New York
Norman J. Rosenberg, M.D., Cleveland, Ohio
Carl E. Rothschild, M.D., Englewood, New Jersey
Andrew C. Ruoff, III, M.D., Paterson, New Jersey
Lyle W. Russell, M.D., Miami, Florida
Paul E. Ruuska, M.D., Seattle, Washington
Otto H. Salsbery, M.D., Covington, Kentucky
Richard Scandalis, M.D., Alhambra, California
Monroe Schneider, M.D., Brooklyn, New York
Julius Schneiderman, M.D., Forest Hills, New York
William H. Schwingel, M.D., Aurora, Illinois
George J. Seaman, M.D., Brooklyn, New York
Sydney Sewall, M.D., Hartford, Connecticut
Paul V. Shannon, M.D., Worcester, Massachusetts
Nathan Shechter, M.D., Rock Island, Illinois
George W. Shelton, M.D., Chattanooga, Tennessee
Ned Manfred Shutkin, M.D., New Haven, Connecticut
Robert S. Siffert, M.D., New York, N. Y.
Stanley David Simon, M.D., Providence, Rhode Island
Frank S. Skopek, M.D., Toledo, Ohio
Robert A. Sobel, M.D., Detroit, Michigan
Carlo Sorrell, M.D., New York, N. Y.
August W. Spittler, M.D., Washington, D. C.

John R. Stacy, M.D., Oklahoma City, Oklahoma
Frank H. Stelling, III, M.D., Greenville, South Carolina
Theodore Booth Strange, M.D., Wilmington, Delaware
Louis J. Strobino, M.D., Utica, New York
William S. Stryker, M.D., Corona, California
Alvin L. Swenson, M.D., Phoenix, Arizona
Leland L. Swenson, M.D., Muskegon, Michigan
Chung Chang Tan, M.D., Fresno, California
Stanley S. Tanz, M.D., Tucson, Arizona
Michael Taranto, M.D., Elizabeth, New Jersey
Lloyd Taylor, M.D., Denver, Colorado
Willis J. Taylor, M.D., Shreveport, Louisiana
Philip C. Trout, M.D., Roanoke, Virginia
Samuel L. Turek, M.D., Chicago, Illinois
Abraham L. Umansky, M.D., New York, N. Y.
Victor B. Vare, Jr., M. D., Phoenixville, Pennsylvania
W. Hunter Vaughan, M.D., El Paso, Texas
William L. Waldrop, M.D., Oklahoma City, Oklahoma
Harry R. Walker, M.D., Oakland, California
Delbert A. Ward, M.D., Boise, Idaho
Francis Leon Ware, M.D., Dallas, Texas
Thomas Pickney Waring, M.D., Savannah, Georgia
William C. Warner, M.D., Jackson, Mississippi
Howard Ayres Wright, M.D., New York, N. Y.
Samuel C. Yachnin, M.D., Passaic, New Jersey
Wayne W. Zimmerman, M.D., Tacoma, Washington

At the second Executive Session, the following officers and committeemen were elected:
President: Harold B. Boyd, M.D., Memphis, Tennessee
President-Elect: T. Campbell Thompson, M.D., New York, N. Y.
Vice-President: Charles N. Pease, M.D., Chicago, Illinois
Secretary: John R. Norcross, M.D., Chicago, Illinois
Treasurer: H. Relton McCarroll, M.D., St. Louis, Missouri
Librarian-Historian: Claude N. Lambert, M.D., Chicago, Illinois
Junior Members of Executive Committee:
William H. Bickel, M.D., Rochester, Minnesota
William M. Deyerle, M.D., Richmond, Virginia
Member of Membership Committee: Edward T. Evans, M.D., Minneapolis, Minnesota
Member of Committee on Scientific Investigation: Carroll B. Larson, M.D., Iowa City, Iowa
Member of Committee on Public Relations: Donald B. Slocum, M.D., Eugene, Oregon
Member of Program Committee: Alvin J. Ingram, M.D., Memphis, Tennessee (Chairman)
Member of Committee on Instructional Courses: William A. Larmon, M.D., Chicago, Illinois
Member of Committee on Audio-Visual Education: J. Vernon Luck, M.D., Los Angeles, California
Nominees to The American Board of Orthopaedic Surgery:
Clarence H. Heyman, M.D., Cleveland, Ohio
Leo S. Lucas, M.D., Portland, Oregon

The presidential medallion was presented to President Francis M. McKeever by Past-President Joseph S. Barr.

The gavel was presented to the new President, Harold B. Boyd, by the retiring President, Francis M. McKeever.

The Annual Dinner was held on Wednesday evening, January 28, at which time the Kappa Delta Award was made. Dr. Charles Gregory and Dr. George J. Garceau were the recipients of this award. Other awards were made as follows:

Scientific Exhibits

Gold Medal Award

1. David Bosworth, M.D., Howard Wright, M.D., and Joseph Fielding, M.D., New York, N. Y.
   Bone and Joint Tuberculosis—Treatment with Marsilid.
2. R. Beverly Raney, M.D., Ernest H. Wood, M.D., C. A. Bream, M.D., and James G. McClure, M.D., Chapel Hill, North Carolina.
   King-Sized X-Rays.

Certificate of Merit

1. Herbert C. Fett, M.D., Donald J. Magilligan, M.D., James C. Barnett, M.D., and Herbert C. Fett, Jr., M.D., Brooklyn, New York.
   Further Studies on Horizontal Lateral Roentgenography of the Hip in Children.
2. Howard A. Mendelsohn, M.D., and Seymour L. Alban, M.D., Los Angeles, California.
   Complications Following Replacement Arthroplasty of the Hip.
3. Sylvester J. O'Connor, M.D., and Carl E. Badgley, M.D., Ann Arbor, Michigan.
   Retention of Foetal Position.
4. Clifford C. Taylor, M.D., and Carl D. Martz, M.D., Indianapolis, Indiana.
   Oblique X-Ray Studies of Hip Dislocation.

Gadget Exhibits

Certificate of Merit

1. Joseph E. Brown, M.D., Cleveland, Ohio, and Lyman Smith, M.D., Elgin, Illinois.
   An Obliquely Corrugated Staple for Firm Fixation of Cancellous Bone.
2. T. Campbell Thompson, M.D., New York, N. Y.
   Template and Temporary Fixing Device for Use During Intramedullary Nailing.

Audio-Visual Program

Gold Medal Award

C. E. Irwin, M.D., Warm Springs, Georgia.
Iliotibial Band Syndrome.

Certificate of Merit

1. R. A. Murray, M.D., Temple, Texas.
   Reconstruction of a Severely Injured Forearm.
2. LeRoy Abbott, M.D., San Francisco, California.
   Surgical Approaches to the Hip Joint.

Special Certificate of Merit and Gratitude was presented to Professor Oscar Scaglietti, Florence, Italy, for his film on "Congenital Dislocation of the Hip."

The American Academy of Orthopaedic Surgeons will hold its Twenty-first Annual Meeting at the Palmer House, Chicago, Illinois, January 23 to 28, 1954. The 1955 meeting is to be held at the Statler Hotel, Los Angeles, California, January 29 to February 3, 1955.

AMERICAN SOCIETY FOR SURGERY OF THE HAND

The Eighth Annual Meeting of the American Society for Surgery of the Hand was held in Chicago on January 23 and 24, 1953, preceded by a Clinical Day in Milwaukee. The program for the Clinical Day was planned by Dr. William H. Frackelton, President of the Society.

THURSDAY, JANUARY 22, 1953

Clinical Session at the Columbia Hospital, Milwaukee.

The morning portion of the program consisted of the presentation of a large and interesting group of patients. These were presented by DR. WILLIAM H. FRACKELTON [1] and DR. JOHN P. DOCKTOR [2] and included cases of congenital hand deformities, tumors, Dupuytren's contractures, burns, tendon injuries, nerve injuries, finger-tip losses, compound injuries, crush injuries, phalangization problems, degenerative changes from trauma, ischaemic paralyses, and some assorted neurological problems.

A large group of cases of syndactylism were presented. These patients were all children and it was pointed out that, if only the soft tissues were involved, repair should be done between the ages of four and six years. If there was bony union of the fingers, a preliminary procedure was done to separate the fingers; and the use of a small split graft was advocated. This was done as early as possible, and a definite separation of the soft tissue was postponed until a more suitable age was reached. It was interesting that the mothers of many of these patients also had syndactylism. Dr. Frackelton was asked why he did not operate on the mothers, and he pointed out that very few of them had the time or the inclination to have the surgery done. Most of them had become accustomed to the cosmetic defect and they had become adjusted to the functional loss.

The problem of lymphoedema of the arm and hand following radical mastectomy was discussed. A most interesting patient was demonstrated who had been seen because of a massive lymphoedema. Measures to improve this had consisted of elevation of the hand and arm at night. This was accomplished by hav-

[1] 324 East Wisconsin Avenue, Milwaukee 2, Wisconsin.
[2] Columbia Hospital, Milwaukee, Wisconsin.

ing the patient wear a heavy glove which was suspended from a pole at the side of the bed. The patient had also been fitted with a special heavy type of elastic gauntlet for the entire arm. This had been tailor-made to her measurements.

A group of patients who had been operated on for Dupuytren's contracture were demonstrated to illustrate the great individual variation in postoperative recovery time which occurs in this disease.

Many patients with tendon and nerve injury were seen. For the tendon grafts, the extensor tendons of the foot seem to be preferred. No motion was started for at least three weeks.

Finger-tip losses were treated with a variety of grafts; free grafts, body pedicles, and cross finger flaps were employed. The cross finger flaps were of special interest since they are probably less widely used. Results, however, compared favorably with the use of body pedicles and were an improvement over the free-graft technique.

Many complicated reconstructive problems were shown, and much interesting discussion followed.

After the presentation of patients, various subjects were discussed. Summaries of these discussions follow:

Serum Neuritis. Dr. John L. Garvey [3] discussed the syndrome of serum neuritis following the use of anti-tetanic serum in connection with his personal experience with twenty cases since 1938. He had interested himself in all unexplained cases of local and generalized neuritis. Only one patient came to the examiner after the diagnosis had been made elsewhere.

There are several explanations for the fact that the condition is not readily recognized: Usually no history is given of a trivial injury or the use of serum; symptoms of serum sickness may be mild. During serum sickness the severe pain may not be recognized as due to nerve-root pressure, but may be attributed to the arthralgia of serum sickness.

The typical syndrome as characterized by a mild or severe type of serum sickness is associated with a radicular pain, followed by paralytic phenomena of the lower-neuron type, without loss of superficial sensation to any degree. The condition may be generalized or localized to a plexus or single nerve. In the author's series, six were generalized; ten were localized in one or both shoulder girdles.

In two cases the condition was associated with cerebral manifestations of serum sickness which at first overshadowed the neuritic symptoms.

Patients with mild involvement recover promptly. Permanent disability results in about twenty per cent. and the healing period may extend over twenty-four months.

This complication of serum sickness should not preclude the use of antitetanic serum for prophylaxis against or for treatment of tetanus, as it is still regarded as the best method of controlling this serious disease.

Causalgia. Dr. David Cleveland [4] stated that the word "causalgia" is now used to cover the syndrome classically described by Weir Mitchell in 1864, and a second group of entities classified by Homans as minor causalgias.

The major causalgia of Mitchell resulting from injuries to large nerves, usually the median or tibial, is characterized by thin, smooth, glossy and blotchy red skin. The pain is severe and is incited by the slightest stimulation, such as the blowing of a breeze, a loud noise, jarring steps, or the touching of the body with a dry hand. The patient seeks refuge in a quiet, darkened place and, with increase in the pain, he becomes tense and nervous with a haunted, fearsome expression. The hand or foot is frequently kept moistened to the point of skin maceration. The nerve is seldom completely divided and is always bound down in fibrous muscle at the site of injury.

The minor causalgias result from minor traumata, such as wrenching, bruising, or crushing injuries, followed by incomplete splinting, physical therapy, or post-traumatic care. The pain is severe and out of proportion to the trauma and is paroxysmal early in its course; later, it becomes chronic. The part is swollen, oedematous, cyanotic, and is held rigid and protected. The joint capsules are thickened and oedematous, and fixation of the joints occurs from lack of motion. Decalcification results from increased blood flow. The patients become emotionally unstable from the pain.

Treatment of major causalgia is adequate sympathectomy and nerve repair. Treatment of the minor causalgias is adequate splinting and early physical therapy, as well as sympathetic blocks. Adequate sympathectomy followed by physical therapy may be necessary if the pain becomes fixed. Amputation-stump neuralgia should not be classified with the causalgias and cannot be relieved by sympathetic interference. Resection of the neuroma and scarred blood vessels, followed by their burial in healthy tissue, is the treatment early in the disease. Later, surgical procedures on the central nervous system may be necessary to relieve the pain. The pathogenesis of the causalgias is not known. It is considered by some to be local sensory-nerve and sympathetic-nerve short-circuiting. By others, including the author, it is considered to be due to abnormal vasomotor reflexes. Very satisfactory results have been obtained from proper and adequate therapy.

Trichlorethylene Anaesthesia for Surgical Care of Hand Cases. Dr. J. W. Temple [5] presented a brief

[3] 208 East Wisconsin Avenue, Milwaukee 2, Wisconsin.
[4] 324 East Wisconsin Avenue, Milwaukee 2, Wisconsin.
[5] Director of Anaesthesiology at Columbia Hospital, Milwaukee, Wisconsin.

summary of the possible uses of trichlorethylene in the field of hand surgery, its advantages and limitations.

It should always be kept in mind that this agent should be used as an *analgesic* agent and not as a complete anaesthetic. If this point is remembered, trichlorethylene may be used in a variety of minor surgical cases such as cleansing and débridement of burns, suturing of minor lacerations, and reduction of simple fractures. Recently he has also found it to be of value in alleviating tourniquet pain in patients with injuries operated upon under local anaesthesia.

The main advantages of trichlorethylene are that it can be administered with a relatively simple apparatus; it is non-explosive and non-inflammatory; it is non-irritating; and there is practically no incidence of nausea or vomiting following its administration.

Its only adverse effects are noted on the cardiac and respiratory systems. It tends to produce a bradycardia, occasional extrasystoles, and a tachypnoea. These effects occur, however, only if the agent is inadvertently administered in too high a concentration, and they can be controlled by promptly reducing the percentage of trichlorethylene in the anaesthetic mixture.

It is not suggested that trichlorethylene should replace any anaesthetic agent now in use, but, in view of the fact that it produces such a high degree of analgesia and provides such a pleasant induction and rapid awakening from anaesthesia, it should prove to be a useful adjuvant in the anaesthesiologist's armamentarium.

Rehabilitation in Cases of Hand Injury. Dr. Edwin C. Welsh [6] defined the process of rehabilitation as the restoration of a person disabled by disease or injury to the fullest possible physical, mental, social, and economic usefulness, compatible with his disability but to the full extent of his capabilities.

The approach to the problem of treating the injured hand may be divided into six basic phases:

The first deals with the psychological preparation of the patient for the treatment which he faces. The doctor, the nurse, the psychiatrist, the therapists, social workers, and vocational counselors all play a part in this phase. The "team concept" is all-important in the early days of treatment.

The second and most important stage is that of definitive medical and surgical care. Obviously, if the initial treatment is not satisfactory, one cannot hope for a good end result.

The third phase is devoted to prevention of deformity and deconditioning in the unaffected extremities.

In the fourth stage of this program, definitive therapeutic measures are employed by physical and occupational therapy, upon receipt of a prescription from the physician in charge of the case. For best results, early referral is mandatory. Much of the therapy can be done on an out-patient basis, thus affording great financial saving to the patient. Occupational therapy has proved useful, not only in functional work, but also in providing tasks to test work tolerance, and to fabricate splints.

The fifth phase encompasses interviewing and planning by the medical social service workers. Social workers are available in nearly every community through Red Feather organizations.

In the sixth and final phase, the patient should be referred to a vocational counselor who can do aptitude testing, counseling, and selective job placement. Such men are available through State Rehabilitation Services.

Friday, January 23

Palmer House, Chicago

Morning Session

The Scientific Sessions were opened on January 23. The following are summaries of the papers presented:

Unusual Tumors of the Forearm and Hand. A Report on Melorheostosis and Neurofibroma. Dr. Vinton E. Siler [7] presented data and references concerning some unusual tumors of the forearm and hand, the very rare melorheostosis syndrome, and an unusual neurofibroma of the median nerve. There is no apparent relationship between these two types of tumors. *Melorheostosis:* He reviewed melorheostosis describing it as a peculiar form of osteosclerosis with an unusual amount of hyperostosis distributed on the side of a bone, resembling tallow drippings on the side of a burning candle. This new formation of bone progresses slowly, but in time large masses may develop. These produce a visible tumor and pain resulting from pressure on vessels and nerves which finally causes limitation of motion. Fibrotic infiltration of the cancellous portion of the bone and fibrotic replacement of the marrow appear to be the fundamental changes, with no evidence of any inflammatory process. The presence of obliterated capillaries is also suggested by one observer; this may be a sign of ischaemia.

Symptoms depend entirely upon location, extent, and activity. There are no generalized constitutional manifestations. Pain and tumor are the general symptoms, although a tumor may not be present in every case. Pain in varying degrees is almost always a factor, but is rarely severe and never constant.

Diagnosis can be established only by means of roentgenographic examination, which reveals the dense hypertrophic irregular, linear mass apparently present within the marrow. The replacement of the structural

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[7] Department of Surgery, Cincinnati Hospital and Hand Clinic, Cincinnati, Ohio.

reticulation is dense, stony, and opaque and is specifically diagnostic. This patchy linear distribution with its selective localization and its coarse, wavy outline[7] has been confused with other hyperostotic bone conditions.

Dr. Siler reported the case of a negro woman. After he had followed her condition for eight years, roentgenographic studies established a diagnosis of melorheostosis involving the fourth and fifth metacarpal bones and all the phalanges of these two digits. He stated that this case is the fifty-seventh to be reported in the literature. *Neurofibroma:* False neuromata arise from the connective tissue of nerves; they contain few if any nerve fibers and grow either within the nerve and infiltrate it, or rise from without and compress it. They attack not only the peripheral spinal nerves, but also their roots.

Pathologists disagree on the correct classification of these peripheral-nerve tumors. The chief divergences of opinion are concerned with the origin of the tumor and the factors involved in the relationships of the multiple tumors found in von Recklinghausen's disease. The pathological picture of nerve fibroma is necessarily also controversial.

The presence of the mass is generally the major symptom, particularly in cases of a neurofibroma of the forearm and hand. Sensory disturbances and pain are also present when a major nerve trunk is involved. Motor disturbances are rare and do not have serious results.

Clinically, the diagnosis of neurofibroma is difficult and often will not be made unless there is disturbance of nerve function.

A case was reported of a woman, twenty-five years old, with a neurofibroma involving the median nerve extending from the elbow into the hand. A median neurectomy was done and the nerve was resected from a point at the elbow to the transverse volar ligament. The patient experienced a surprisingly complete degree of recovery in the function of her hand.

Cutaneous and Subcutaneous Beryllium Granulomata of the Hand. Dr. J. Edward Flynn[8] said that beryllium copper alloy is used extensively for civilian production and for war-time demands. It has high strength, excessive fatigue resistance, good electrical conductivity, and is non-magnetic, non-sparking, non-rusting, and corrosion resistant.

In processing the ore, beryllium oxide is extracted under high temperatures from the crushed inert ore beryl by concentrated acids and fusion methods. Fumes and dust of by-products, wherein lie the hazards of cutaneous and pulmonary lesions, are present at various stages during the processing.

The specific etiology of beryllium poisoning is unknown. A chemical reaction is probably the cause, as suggested by pathological findings, the clinical course of the disease, and data obtained in the investigation of beryllium. The incidence and severity of reactions are proportional to the degree of exposure and chemical irritation of dust and fumes.

The skin lesions which are caused by beryllium have been classified as dermatitis, cutaneous ulcers, cutaneous lesions occurring spontaneously with chronic granulomata of the lungs, and subcutaneous granulomata.

Previous to 1949, beryllium was used in the manufacture of fluorescent light tubes in this country. Broken fluorescent light tubes have been the cause of most of the subcutaneous granulomata reported in the literature.

Reports of two patients with three granulomata were given in detail. The full report of these cases is available (*Annals of Surgery*, Vol. 137: 265–271, Feb. 1953).

Dr. Darrel T. Shaw[9], in discussing the papers presented by Dr. Siler and Dr. Flynn, said that usually the diagnosis of melorheostosis will be made by the roentgenologist, and he feels that most roentgenologists are alert to the possibility. He doubts that the lesion should be classified as a tumor.

In five adult patients with congenital neurofibroma involving the median-nerve distribution, Dr. Shaw had used a surgical approach of selective resection of the tumor in order to retain and to improve the function of the hand. He felt that complete excision of these tumors would have resulted in great disability.

The warning of the dangers of beryllium is timely. Beryllium is still used extensively; it is used in neon signs. It should be remembered that a subcutaneous granuloma is a localized lesion and remains localized; it does not become systemic. Débridement at the time of injury or complete excision of the granuloma effects a cure.

Dr. L. D. Howard, Jr.[10], commended Dr. Flynn for his thorough coverage of the subject of beryllium granulomata. It is of interest that this metal when in the tissues produces more than the usual foreign-body reaction, presenting a more or less specific histological picture with considerable resemblance to sarcoma. Moreover, when this metal was given intravenously to rabbits, a very malignant bone sarcoma developed after a period of seven months. The disease is relatively new, because beryllium was not used in any quantities prior to the last war. In the differential diagnosis, one might also include puncture wounds from indelible pencils, in which there is also a rather marked tissue reaction, due in this instance to aniline dye in wax. This lesion also needs total excision for cure.

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[9] 1046 Carnegie Avenue, Cleveland 6, Ohio.
[10] 516 Sutter Street, San Francisco 2, California.

Dr. Michael L. Mason[11], commenting upon Dr. Siler's paper, said that he had had experience with only one case of melorheostosis, and that was during the war. This was a boy who entered the hospital because of gradually developing contracture of the right hand. The diagnosis at the admitting office was possible Dupuytren's contracture. It was evident that something else was leading to contractures of the middle and little fingers; there was a little thickening of the bone. X-rays revealed the melted-wax appearance of the bones along the inner side of the arm, forearm, and hand.

The Anatomy and Function of the Intrinsic Musculature of the Fingers. The material presented by Dr. Don L. Eyler[12] is a portion of an extensive study of the embryology, anatomy, and function of the intrinsic mechanism of the hand begun in the Department of Anatomy at Duke University in 1949, and carried on under the direction of Dr. Joseph E. Markee.[13]

The lumbrical muscle enjoys the singular distinction of having its origin on a flexor tendon and its insertion into an extensor tendon. It has an average fiber length of about fifty millimeters, twice that of the interossei, and it inserts almost 100 per cent. into the lateral band of the extensor aponeurosis on the radial side of each digit. Many and varied are the functions ascribed to this small muscle; its importance has probably been overrated. By virtue of its moving origin and its angle of approach at the metacarpophalangeal joint, it is physically best suited to initiate flexion of the metacarpophalangeal joint and to contribute materially to the force of the final phase of grasp.

There are seven volar interosseus muscles in all primates except in man, in whom they are reduced to three by incorporation of numbers one, three, four, and six with the dorsal interossei. Numbers two, five, and seven, commonly referred to as volar interossei one, two, and three in man, pass dorsal to the transverse metacarpal ligament and insert primarily into the lateral bands of the extensor aponeurosis on the ulnar side of the index, and on the radial side of the ring and little fingers, respectively. Only the third volar interosseus gains any significant bony insertion, and this accounts for the fact that in any progressive type of ulnar palsy, the first demonstrable weakness is loss of power to adduct the digits. The volar interossei also act to flex the metacarpophalangeal joint and to extend the interphalangeal joints. In contrast to the lumbrical muscle, which can only incompletely extend the interphalangeal joints of the finger, the volar interossei are able to extend completely the interphalangeal joints of the fingers in all positions of the wrist and metacarpophalangeal joint except one,—that with the wrist completely extended and the metacarpophalangeal joint fully flexed.

The dorsal interossei are four in number and have dorsal and volar components which are variably fused. Each dorsal component is bipenniform and inserts primarily into the base of the proximal phalanx and into the capsule of the metacarpophalangeal joint. The volar component, phylogenetically a volar interosseus, inserts primarily into the lateral band of the extensor aponeurosis with lesser insertion into the base of the proximal phalanx and into the capsule of the metacarpophalangeal joint. The first dorsal interosseus is an exception and gains no insertion into the lateral band of the extensor aponeurosis. The first dorsal interosseus inserts almost 100 per cent. into bone; number two, 60 per cent.; number three, 6 per cent.; and number four, about 40 per cent. into bone. The remaining muscle of each dorsal interosseus inserts into the extensor aponeurosis. The first metacarpal head of the first dorsal interosseus gains some insertion into the transverse fibers of the extensor aponeurosis, as well as into the proximal phalanx, and is an important component of the mechanism of pinch. Its exact function is rather difficult to replace by surgical transfer. The dorsal interossei act to flex the metacarpophalangeal joints and, except for the first, to extend the interphalangeal joints of the fingers. They also act to adduct the digits toward the mid-line of the hand and, under certain circumstances, may even extend the metacarpophalangeal joints. By microdissection one can demonstrate separate nerve fibers to the volar and dorsal components of each dorsal interosseus.

The relation of the intrinsic muscles to the axis of rotation at the metacarpophalangeal joint has much to do with their function. The dorsal component of each dorsal interosseus passes almost directly over the axis of rotation of the joint and is capable of extending, flexing, and abducting the digit it serves. The volar interossei and the volar components of each dorsal interosseus approach the joint well below the axis of rotation of the joint. The lumbrical muscle approaches the metacarpophalangeal joint volar to the transverse metacarpal ligament and is in an ideal position to initiate flexion of the joint and to contribute force to the final phase of grasp.

At the metacarpophalangeal joint there exists a synergistic antagonism between the intrinsic muscles and the extensor digitorum communis. Distal to the proximal interphalangeal joint the potentialities of the extensor digitorum communis and the intrinsic muscles inserting into the aponeurosis are the same. With the metacarpophalangeal joint stabilized by one, the other is capable of completing extension of the interphalangeal joints.

Intrinsic Contracture in the Hand and Its Surgical Treatment. Dr. Crampton Harris, Jr.,[14] and Dr. Daniel C. Riordan[15] stated that contracture of the intrinsic muscles of the hand was first recognized by

[11] 154 East Erie Street, Chicago 11, Illinois.
[12] 1921 Broad Street, Nashville 4, Tennessee.
[13] Duke University School of Medicine, Durham, North Carolina.
[14] 6325 Perrier Street, New Orleans, Louisiana.
[15] 1538 Louisiana Avenue, New Orleans 15, Louisiana.

Bunnell in the Hand Surgery Centers of the large Army General Hospitals during World War II. In these centers, great numbers of patients with injured hands were gathered for treatment, and it soon became evident that contracture of the intrinsic muscles represented an entity hitherto unreported, but not uncommonly found in injured hands.

Clinical picture: Localized contracture makes the intrinsic musculature appear to be acting to a much greater degree than normally; the metacarpophalangeal joints are strongly flexed, and the interphalangeal joints are extended; the thumb is often involved, and becomes clamped into the palm or is strongly adducted against the index finger. This type of contracture may result from one or more of a number of conditions. These may be classified as follows:

Ischaemia: Contracture may result when ischaemia of the hand is brought about from any cause. Many of the patients give a history of injury to the arm, with application of a tight constricting cast which included the hand and was especially tight in the area of the hand. The tissues of the hand, nerves, muscles, fascia, tendons, and skin are subjected to prolonged ischaemia, and the muscles undergo fibrosis and contracture. Other patients may give a history of injury to the arteries in the arm and forearm.

Spasm: Intrinsic contracture may become fixed, if the intrinsic musculature goes into spasm and remains so for an extended period. A typical example of this type of contracture is found in rheumatoid arthritis. Because of the painful condition of the joints, and also because of the direct involvement of the muscles themselves, the small muscles of the hand go into spasm—first in order to protect the painful joints, and second because of direct irritation. If the rheumatic process is severe and prolonged, the position of the hand becomes fixed.

Another etiological factor in this category is leprosy. In this condition, the peripheral nerves are directly attacked by the bacillus of leprosy. There may be rapid and complete destruction of the nerve, resulting in loss of the intrinsic muscles, and a typical claw hand results. In other cases, where the involvement is more gradual, the intrinsic muscles go into spasm caused by the irritative effect of the bacillary infection on the nerve trunk. If the contracture is sufficiently prolonged, the hand becomes fixed in the hyperintrinsic position.

Fibrosis: Intrinsic contracture resulting from direct fibrosis of the small musculature may be due to a number of causes. One of the most typical varieties is that seen following thermal injuries, in which the muscles and soft tissues are damaged or destroyed as a result of direct injury by heat. Subsequent replacement of the muscle by fibrous tissue, which contracts as it becomes mature, results in the typical hyperintrinsic or "intrinsic-plus" deformity. Direct traumatic injury to the hand may cause isolated contractures.

Functional loss in the "intrinsic-plus" hand: The metacarpophalangeal joints are held in the flexed position and, as a consequence, no abduction of the fingers is possible. The most crippling aspect of the condition is the inability to flex the fingers in any position of the metacarpophalangeal joints except at 90 degrees of flexion. Pinch and grasp are therefore lost. The deformity is quite as disabling as the reverse deformity of the claw hand.

Clinical test for intrinsic contracture: If we fully flex the metacarpophalangeal joints, the interphalangeal joints may also be fully flexed. If we extend the metacarpophalangeal joints, thus using up the limited excursion of the intrinsic musculature, then the interphalangeal joints extend and cannot be flexed even forcibly so long as the metacarpophalangeal joints are held in extension.

Surgical treatment: Littler has modified Bunnell's method of lateral-band section; and this is considered by the authors to be the treatment of choice in this condition. One may think of the extensor aponeurosis as having three components,—the long extensor tendon, the transverse fibers which flex the metacarpophalangeal joints, and the oblique fibers which extend the interphalangeal joints. Littler suggested that the oblique fibers be excised, thus releasing the extensor contracture on the interphalangeal joints, but preserving the transverse fibers which exert a flexor action on the metacarpophalangeal joints. So long as the flexor action of the transverse fibers is preserved, we know, from Fowler's concept, that the interphalangeal joints can be completely extended by the long extensor tendon.

The virtue of this procedure is that it restores the vital functions of pinch and grasp, preserves finger extension and flexion, and does not in the least inactivate the abductor-adductor function of the intrinsic muscles at the metacarpophalangeal joints.

Surgical technique: Atraumatic technique is important. The authors believe that the best approach is through a single dorsal mid-line incision, extending from the level of the metacarpophalangeal joint to about the level of the proximal interphalangeal joint. Through this single incision, both sides of the extensor aponeurosis can be visualized, and the appropriate portion of the extensor aponeurosis can be excised. After the proper portion has been excised, the interphalangeal joints should be fully flexed, with the metacarpophalangeal joints held at 180 degrees, in order that all contractural elements may be released. After completion of the freeing of the involved fingers, the incisions are closed with a running suture of No. 36 stainless-steel wire, and a pressure dressing is applied. A volar plaster splint is applied which extends slightly past the metacarpophalangeal joints, and prevents any flexion of the metacarpophalangeal joints, but permits full flexion of the interphalangeal joints. In this way the patient can actively exercise his fingers on the first postoperative day, and the mobility gained at the time of operation may be preserved.

In discussion, Dr. S. Benjamin Fowler[16] pointed out that when the flexor digitorum profundus

[16] 1921 Broad Street, Nashville 4, Tennessee.

of a digit, particularly the index finger, is severed distal to the point of origin of the lumbrical muscle, the flexor profundus muscle contracts and thus advances the origin of the lumbrical muscle and puts it under stretch. We can often observe in such a finger that the interphalangeal joints cannot be completely flexed with the metacarpophalangeal joints extended. This must be due to advancement of the origin of the lumbrical and its increased tension because the interosseus muscles themselves have suffered no disturbance. This advancement of the origin of the lumbrical may therefore interfere with flexion of the interphalangeal joints. It may interfere with the excursion of the flexor profundus tendon and thus compromise the result of a free tendon graft. He, therefore, feels that in instances where it is observed to be tight, the muscle should be sectioned or sacrificed.

In a severe "intrinsic-plus" hand, the authors note that there may be incomplete extension of the distal phalanx. This is due to hyperextension of the mid-phalanx which then prevents the distal portion of the extensor aponeurosis from acting completely on the distal phalanx. In the "intrinsic-plus" hand occasionally lengthening of the central slip over the distal end of the proximal phalanx will restore balance to the finger with the effective extension of the distal phalanx. In some of his cases, he was unable to get the metacarpophalangeal joint to extend to 180 degrees after intrinsic section because of contracture of the anterior capsule.

It should also be noted that, in a paralysis of intrinsic muscles due to a nerve lesion, a little ischaemia of the intrinsic muscles is often a good thing as they will stabilize the metacarpophalangeal joints to the extent that the long extensor tendons can afford very satisfactory extension of the interphalangeal joints.

Dr. J. William Littler[17] stated that the intrinsic lumbrical and volar interosseus muscles serve primarily to flex the metacarpophalangeal joint, thus maintaining the longitudinal arch of the hand.

Contracture or paralysis of the intrinsic musculature will disrupt the longitudinal arch. Both conditions require corrective procedures through intrinsic tendon release, tendon transfer, or metacarpophalangeal arthrodesis if finger function is to be restored.

A mild contracture of the intrinsic muscles in median-nerve and ulnar-nerve paralysis prevents hyperextension of the proximal phalanx.

Because a severe ischaemic intrinsic-muscle contracture may result from a constricting plaster cast which compresses the metacarpals, extreme care must be exercised whenever plaster is utilized for immobilization. An injured hand, properly immobilized and elevated, should be reasonably comfortable; excessive or persistent pain often indicates a tight dressing and relief is mandatory for the prevention of ischaemic skin and muscle complications.

Dr. Sterling Bunnell[18] said that Dr. Eyler and Dr. Markee have shown us how the lumbricals, which have a 50-millimeter muscle-fiber length and consequently a long excursion, have also a 35-degree angle of approach and so initiate flexion of the metacarpophalangeal joints. They also have shown how the interossei with a 25-millimeter muscle-fiber length and only a 25-degree angle of approach have a shorter but a stronger pull.

They have shown how the intrinsic muscles stabilize the metacarpophalangeal joints in flexion so that the long extensors can extend the interphalangeal joints and how the long extensors stabilize the metacarpophalangeal joints in extension so that the intrinsics can give lateral motion and extend the interphalangeal joints.

This synergistic and coordinated action allows the long extensors better to extend the interphalangeal joints when the metacarpophalangeal joints are flexed and the intrinsics better to extend the interphalangeal joints when the metacarpophalangeal joints are extended.

He said that, to distinguish it from Volkmann's ischaemic contracture, he had given it the rather ponderous name "ischaemic contracture, local, in the hand". We must also, however, consider cases of intrinsic contracture which did not develop from ischaemia such as a muscle fibrosis as a part of rheumatoid arthritis and even functional postures that have become fixed from long duration. The authors add the early spasm accompanying both rheumatoid arthritis and some cases of leprosy. Perhaps a fitting term for the condition is "intrinsic contracture of the hand". This would include the ischaemic hand and the non-ischaemic contractures. The ischaemic type is common and in all degrees. (Dr. Bunnell's review of such cases has already been published in *The Journal of Bone and Joint Surgery*, 35-A, 88–101, January 1953.)

He feels that the main disability is inability to open the hand for grasp. To the authors it is inability to flex the interphalangeal joints unless the metacarpophalangeal joints are flexed to a right angle. There is a difference here in the fundamental conception and so also in the treatment. In the true ischaemic hands, the metacarpophalangeal joints of both fingers and thumb are drawn into strong flexion and the interphalangeal joints are in extension. These hands can always make a fist for grasping but they cannot open for grasp.

Therefore, the two methods of treatment he has used are either to strip the interossei and to displace them distally to relax the lateral bands or to break the continuity of the lateral bands themselves.

The Cornpicker Hand. Dr. Frederick S. Webster[19] first showed photographs of the machinery

[17] 16 East 90th Street, New York 28, N. Y.
[18] 516 Sutter Street, San Francisco 2, California.
[19] 2659 Ryons Street, Lincoln, Nebraska.

responsible for this specific type of hand injury commonly seen in the Corn Belt. In spite of instructions from every manufacturer of mechanical cornpickers, operators attempt to unclog the machine without shutting off the power. As the hand is caught in the moving mechanism, severe injury results, which represents the combination of lacerations, crushing, avulsion, and friction burns. There are three main types of injury: The first consists of loss of all fingers but not of the thumb; the second is the loss of all fingers and the thumb; and the third is the loss of the thumb and one or more fingers on the radial aspect of the hand. The last form is the least common.

The treatment is usually prolonged and requires multiple surgical procedures; the simpler solution of amputation proximal to the wrist joint is to be avoided. The value of saving all the remaining portion of the hand possible was stressed and its usefulness was illustrated. The routine procedure of treatment was described, including débridement and the coverage of skin with split-thickness and later with full pedicle grafts. Reconstruction of these severely traumatized hands is varied and, although this was not outlined in detail, the same principles apply to the treatment of these hands as to those similarly injured by other forms of trauma. Usually some type of bone work is required and among the illustrations were those showing the value of excision of certain of the metacarpals for deepening of the cleft and permitting opposition or pinch between the remaining digits and the thumb.

The problem of prosthetic appliances for these hands was also discussed. These patients are not primarily interested in the cosmetic result, but they need appliances which will stand the requirements of heavy farm work. Some relatively simple special prosthetic attachments were shown. It is most important to realize how efficiently some of these simple devices work and how the patients utilize what they have left of their hands. Without exception, all of those in whom all the hand possible had been spared have expressed their appreciation as they have adapted the extremity to a surprising degree of usefulness; none have requested amputation.

In discussion of this paper, Dr. Julian M. Bruner [20] spoke of seeing seven severe cases during the past season at Veterans and private hospitals. The most common type of this serious injury has been the amputation of fingers—the thumb and the fifth finger escaping injury most frequently. Usually the metacarpal region is also severely damaged in its distal portion, the soft tissue overlying the metacarpal heads being severely crushed. He considered Dr. Webster's presentation timely, clear, and concise, and endorsed the principles of treatment advocated by him as sound and practical.

Since many of these wounds are grossly contaminated with soil, and since débridement is often necessarily conservative, the danger of gas gangrene and tetanus is considerable.

Frequently all that one can do in these injuries is to salvage as many fingers as possible, being conservative with those of doubtful blood supply. If the thumb escapes, and the fifth finger can be saved, a very useful hand results. If the thumb escapes and all fingers must be disarticulated at the metacarpophalangeal joints, it is imperative to save the entire metacarpal area of the hand if possible. Even with all fingers missing, if the farmer has a good thumb and an intact metacarpus, he can do many types of heavy farm work.

The psychic effect of such major injuries of the hand on an active farmer is one of terrible depression, and the patient must get back to some degree of physical activity as soon as possible even while his hand is completing its recovery.

Dr. Carroll O. Adams [21] stressed the importance of preparation of the patient psychologically for what he faces in the future. He is very often a young person and quite unstable; he comes into the hospital very much excited and greatly worried, knowing it was his own fault. He should be educated to know that the ultimate mechanical function is the first consideration, with the cosmetic result secondary. He must be shown that it is worth while to take time and energy and money in an attempt to save the hand. He should be told to start with that, if he is to get the maximum result, there may have to be multiple operations. One fortunate thing is that these patients have all winter in which to have this work done. The average farmer is least busy from October, when most of these injuries occur, until March or April. The hand should be in good condition by the time the spring plowing starts.

Friday, January 23

Afternoon Session

Mangle Burns and Severe Wringer Injuries in Children. Dr. Joseph L. Posch [22] described the mechanism of wringer injuries which have been recognized in children since the advent of the power-driven washing machine. A child places his fingers and hand between the moving portion of the wringer. The rollers are stopped either at the hand, at the supracondylar area, or at the axilla. Severe tissue destruction usually occurs where the rollers have stopped.

Mangle injuries are caused in a similar manner. The child is attracted by the moving portion of the roller and a severe roller type of injury occurs, as well as a burn from the shoe of the iron. These accidents usually happen in the younger age group.

The severe nature of the injury is usually not recognized at first. It includes compression of the tissues, ischaemia, swelling, and extravasation of blood into the tissues.

[20] 1005 Bankers Trust Building, Des Moines 9, Iowa.
[21] 102 North Washington Avenue, Mason City, Iowa.
[22] 1410 Kales Building, Detroit 26, Michigan.

Treatment should consist of observation and a compression type of dressing with the hand and forearm wrapped in a large pressure dressing. The extremity is then elevated. If the skin is broken, it should be treated like any other open wound. Frequent aspiration of hematomata often cuts down the incidence of necessity for skin-grafting.

In severe destruction where there has been loss of skin, débridement may be carried out at the end of one week and, after demarcation of devitalized tissue has occurred, skin-grafting may be done at that time. In some cases, the area is allowed to slough, is debrided, and then skin-grafting is done between the fourteenth and twentieth day.

The original dressing is a split-thickness skin graft which acts as a temporary covering to control infection. As one would expect, contracture occurs and later this is covered with a full-thickness skin graft. Occasionally, one may be able to apply a rather thick split-thickness skin graft which will not contract too severely. In severe destruction of tendons and nerves of the hand, the tube-pedicle type of graft is indicated.

Postoperatively these grafted hands are dressed in a large compression dressing with complete immobilization. At the end of one week, under general anaesthesia, the dressing is changed and the sutures are removed. The hand is redressed in a large splint, and at the end of another week the dressing is entirely removed and the grafted area is left exposed. Immobilization is maintained on another splint for one more week, day and night. After that the child wears the splint at night for two to three months and uses his hand during the day.

Dr. George S. Phalen [23] discussed Dr. Posch's paper. He agreed fully with the treatment outlined. He emphasized the ease with which the diagnosis may be missed and the disastrous consequences of failure to initiate the appropriate treatment. The severe oedema of the hand which is certain to develop over the next twelve to twenty-four hours may take many weeks to disappear and may easily leave in its wake some residual stiffness and deformity of the small joints of the hand as well as some fibrosis along the tendon sheaths.

Adults receive mangle and wringer injuries and hospitalization of these patients is much to be preferred. He had occasionally employed cervical sympathetic blocks to aid in the control of severe oedema and asked Dr. Posch if he had used stellate blocks in the treatment of any of his patients.

Dr. S. M. Dupertuis [24] had found that free split grafts of approximately one-half thickness of the skin applied to granulation surfaces at the proper time usually take well and provide definitive surface coverage not requiring later replacement. Split-thickness skin grafts to replace dorsal scar contractures are excellent, since the hand in the normal flexed position of rest or function stretches these grafts and shrinkage or tightness is seldom seen. The replacement of contracted burn scar on the palm, however, usually requires a free full thickness graft, because of a natural tendency to contract and wrinkle, but on occasions a split graft of approximately three quarters thickness provides an equally good result.

In the early treatment of burns on the dorsum of the hand, his experience had been that of Braithwaite, who advocated surgical excision of the slough by the twelfth day with immediate application of a split-skin graft to prevent fibrosis of the delicate dorsal extensor mechanism. In 1950, W. P. Dallas Ross, of England, had presented a splendid report on the treatment of 323 burned hands, in which he did immediate excision of the localized burned area with application of free skin grafts in fifty cases. Five deeper burns required immediate abdominal pedicle flaps, and he reported excellent results in all cases with a 40 per cent. reduction in hospitalization. Since localized burns of the hand present little or no problem of generalized shock, immediate excision and grafting reduces greatly the necessary period of immobilization, eliminates absorption from granulation areas, and should prove the preferred method of treatment for localized burns of the hand.

Dr. John Bell [25] showed slides of a child who had been burned by a hot mangle and was initially treated by careful cleansing, immobilization, and a pressure dressing. On the fifth day a surgical excision was done. The slide showed the necrotic area on the dorsum of the hand. The next slide showed the wound after the necrotic tissue had been removed. There followed, immediately, the application of split-thickness grafts to close the wound. The next slide showed the follow-up photograph with the split-thickness skin graft in place and contraction of the graft developing. Nine months later the split-thickness skin graft was excised and a full-thickness graft was applied to the dorsum of the hand.

The next case was somewhat similar but the burn was deeper. Surgical excision of the slough was performed and a split graft was immediately applied. This split-thickness skin graft contracted rather rapidly and as a result a full-thickness graft was applied. The last slide showed the degree of function attained after healing of the full-thickness skin graft.

Dr. William H. Frackelton [1] said that in addition to the pathological changes of wringer and mangle injuries which had been brought out there is not only a crushing factor, but in the extraction there is a tearing factor. That tearing factor is over and above that of contusion and crushing. There is a tearing of the vascular network between the subcutaneous tissue and the underlying fascia. An arm and hand is left on which it is possible to use a sleeve graft.

Dr. Joseph L. Posch, in closing, said that cervical sympathetic block should be of aid in reducing the

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[24] Medical Arts Building, Pittsburgh 13, Pennsylvania.
[25] Northwestern University Medical School, Chicago 11, Illinois.

swelling in severe injuries. In addition, one could consider the use of hyaluronidase. This would also probably aid in decreasing the oedema. He knew of one instance in which it was used with remarkable effect.

Once the granulating area has been covered with a split-thickness graft, the question arises as to when the final full-thickness graft may be applied. He allowed the graft to contract until the maximum amount had occurred. This usually takes from six to eight weeks. He rarely waited longer than this because in a growing child there will be a tendency for deviation of the digits to occur, especially if the contracture is on one side of the finger. He felt it was important, as Dr. Phalen emphasized, that an adequate dressing be applied to the hand of these children. A large compression dressing extending from the finger tips to the upper arm should be applied. Unless this is fastened securely with safety pins and adhesive tape, it will surely become loose. He had had this happen on several occasions. However, with adequate fastening the dressings will remain intact, and should be changed at the end of one week under anaesthesia.

The Effect of Cortisone on Healing of Tendons in Rabbits. Dr. Gordon Grant [26] stated that tendinous and peritendinous structures are mesenchymal in origin, and cortisone and ACTH exert their principal effects in tissues of this variety. The chief therapeutic effect of either is seen in the collagen diseases, where there is some impairment of the body's ability to prevent excessive fibroplasia.

Peritendinous adhesions are the principal cause of failure in repair of tendons of the hands. It was apparent from the beginning that either hormone might be valuable in hand surgery if it could prevent or greatly inhibit peritendinous and capsular adhesions; but neither hormone could safely be used if it were to inhibit the union of tendon ends or otherwise interfere grossly with the healing of wounds.

Sixty rabbits were used in the experiment described; they were divided into two series of thirty each. Ten animals were used as controls in each series; the other twenty were given cortisone from the day of operation to the day of sacrifice. In each series all thirty animals underwent operation on the same day. The hair was clipped from the area overlying that group of plantar flexor tendons corresponding to the tendo achillis in the human. Each tendon bundle was divided halfway through and promptly repaired with a double-right-angle silk suture. Twenty thousand units of penicillin in aqueous solution were injected into each operative site.

In Series A each test animal was given from the day of operation onward a daily dose of cortisone of 3 milligrams per kilogram of body weight (the equivalent of 200 milligrams daily for a 150-pound human). In Series B each test animal was given 7.5 milligrams per kilogram of body weight (the equivalent of 500 milligrams daily for a 150-pound human). In each series one control and one test animal were sacrificed on alternate days from the eighth to the twenty-eighth day after tenotomy and repair. Transverse sections were cut from each skin wound. The gross state of healing of each tendon juncture was noted and sections were cut from each.

Results: There were no hematomata and no infections. There were no separations of any skin wounds and there was no evidence that the tensile strength of the skin wounds was less in the test animals than in the control animals. Peritendinous adhesions appeared to reach about the same degree in the test as in the control animals.

Microscopically there were many new capillary loops and new fibroblasts in all sections examined. The normal palisading was noted in all sections from the twelfth day onward.

Conclusions: This is a negative report, and, as such, is at variance with the majority of clinical and experimental reports.

They have now given cortisone to eleven patients operated on for Dupuytren's contracture and to ten patients undergoing direct repair or grafting for flexor-tendon injury. The dosage has been 100 milligrams three times a day, regardless of the weight or sex of the patients, all of whom have been adults. There have been no instances of failure of wound healing, and no evidence that any tendon juncture was adversely affected. These patients have seemed to have less pain and less oedema of exposed digits; they have seemed to mobilize their affected hands more swiftly.

Experimental Tendon Repair within the Flexor Tunnels: The Use of Hydrocortisone without Improvement of Function in Dogs. Dr. Richard I. Gonzalez [27] said that, in the hope of improving function following primary tendon repair within the flexor tunnels, 0.5 cubic centimeter of hydrocortisone was injected about the site of suture in dogs at the time of repair.

In eight dogs, the flexor profundus was repaired by suture at a distance. The profundus tendon to the index finger was used as the experimental tendon, and the profundus tendon to the little finger as its control. After three weeks' immobilization, the tendons were tested for function, and for tensile strength. In none of the eight dogs was the function of the experimental tendon improved over that of its control; and in all of the dogs the tensile strength of the experimental and control tendons was essentially equal.

From this small series it was concluded that the local use of hydrocortisone does not improve the function nor interfere with the healing of tendons repaired within the flexor tunnels.

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[27] San Mateo, California.

The Use of Compound F, Hydrocortone, in Operative and Non-Operative Conditions of the Hand. Dr. Lot D. Howard, Jr.[19], Dr. Sterling Bunnell[18], and Dr. Donald R. Pratt[28] explained that Compound F, also known as hydrocortone, is a synthesized adrenal cortical hormone. It is marketed as a crystalline suspension in saline for intra-articular injection. The properties of hydrocortone are identical with those of cortisone except that its influence occurs at the tissue level where the drug is injected; systemic effects, therefore, are not noted in the use of the small dosage. The drug has been reported to have favorable action in rheumatoid and osteo-arthritis, but for other than intra-articular injection very little appears in the literature.

In the present series, Compound F had been used in seventy cases of hand conditions of both operative and non-operative types, the distribution of cases being as follows:

Tenosynovitis	11
Trigger finger	12
de Quervain's tenosynovitis	3
Hard dorsal oedema of the hand	2
Ganglia	5
Rheumatoid arthritis	2
Osteo-arthritis	3
Dupuytren's contracture (postoperatively)	9
Tendon freeing	6
Tendon suture	4
Postoperative reconstruction	9
Miscellaneous	4
Total	70

The results in general were good in cases of rheumatic origin, including arthritis, tenosynovitis, trigger finger, and the tendency of the fingers to stiffen following operations on Dupuytren's contracture. The drug was also found useful when given postoperatively in the wound following major reconstructive procedures on the hand. There have been no complications which can be exclusively ascribed to the use of the drug. Compound F has the temporary effect of minimizing inflammatory reaction in non-operative conditions and in the immediate postoperative phase following surgery. The drug can in no sense be considered a cure.

Dr. Elden C. Weckesser[29] described briefly some work done in the last two years with the use of cortisone in the prevention of adhesions. The results obtained by his group were much the same as those of Dr. Grant and Dr. Gonzalez. The original work had been carried out in the peritoneal cavity with the expectation of doing tendon work later if the findings warranted. It involved denuding the small intestine in the experimental animal and using 10 milligrams per kilogram of body weight of cortisone intramuscularly each day. Repeated observations were made by successive laparotomies and the number and extent of adhesions were measured over a period of time. In essence, if cortisone was started on the day of the denuding operation, there was no difference between the experimental and control groups. If the drug was taken for one week prior to operation, there was some difference. In no instance were adhesions completely prevented in the peritoneal cavity. It was noticed that, as the animals received the drug over a long period of time, there was a difference in wound healing, but this was not great. These animals were subjected to successive operations while on cortisone. The work on tendons was not undertaken because the results on the peritoneal cavity did not warrant it. He was very much impressed by Dr. Howard's presentation.

Osteoid Osteoma in the Hand. Dr. Robert E. Carroll[30] spoke of the role of osteoid osteoma in the hand. In general, the clinical history of osteoid osteoma presents no association with trauma. Pain is of a persistent aching nature and is relieved by aspirin. There is swelling of the affected member. The patients are young,—in the second and third decades of life.

The x-ray picture is the most useful aid in the diagnosis. The nidus is either radiolucent or of a type known as a "ring sequestrum". Three locations are found for the nidus—the medullary cavity, the cortex, and the periosteum. The most common location is in the proximal phalanx of the hand. The carpal navicular bone is found to be also frequently involved. The treatment is surgical excision of the nidus. No antibiotic has been effective.

Dr. Carroll reported six cases: in three the second metacarpal was involved, in one the cortex of the proximal phalanx of the index finger, in another the periosteum of that finger, and lastly, the first metacarpal.

He had collected twenty-two cases from the literature, making a total of twenty-eight reported.

Dr. Michael L. Mason[31] stated that in a recent article (Acta Radiologica, 38:279–293, 1952) Moberg has fully discussed the usual roentgenographic appearance of the lesion and has brought out the fact that, although the x-ray appearance is usually characteristic, confusion may arise in the case of bone abscess, osteitis without abscess, syphilitic osteitis, or even a healing march fracture.

In a patient whom he had seen, the swelling of the finger resembled a spina ventosa, although the x-ray

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appearances were typical of osteoid osteoma. This patient, who was cared for by Dr. Sumner Koch, is particularly instructive in that films taken over a period of two years show the typical course of the lesion. Two years previously the patient, a boy of twelve, had suffered a longitudinal fracture of the proximal phalanx of the right index finger. Healing was uncomplicated. One year later swelling appeared and night pains developed, easily controlled by aspirin. There was no interference with motion. X-rays taken at that time showed the barest suggestion of periosteal thickening. One month later films showed a definite area of lucency in the distal end of the phalanx, along with increased thickening of the cortex. Two months later these roentgenographic findings were still more marked. By the time he was seen the area of lucency was still larger and the cortex markedly thickened. At operation the thick cortical bone was chiselled away and a granulomatous marrow was exposed. Apparently not all of the nidus was removed, because the pain and swelling reappeared in some three months and films at this time showed the area of lucency as before. This area was then completely removed, leaving only a thin bone shell. Pain and other symptoms subsided and after three years there has been no recurrence.

Congenital Arteriovenous Fistulae of the Hand. Dr. Raymond M. Curtis [31] stated that it is possible, with careful planning, to eradicate surgically even extensive congenital arteriovenous fistulae of the hand and still preserve hand function.

Multiple arteriovenous fistulae of the hand, in most instances, have originated from a congenital remnant as a result of a failure of the common embryonic anlage to differentiate into true artery and vein. It may be possible for such abnormal communications to develop from the normal arteriovenous communications which occur in the hand, known as the neuro-arterial glomus, when this structure becomes uncontrolled as a result of damage.

Clinically, the multiple arteriovenous fistulae are manifested by varicose veins of the extremity which may be brought to one's attention when a patient presents himself with a wound which fails to heal. The skin temperature of the affected part is usually higher than that of the normal member. A bruit and a thrill may or may not be elicited over the communications, depending upon the caliber of the anastomotic channels. The bradycardiac sign may be demonstrable. The oxygen saturation of the venous blood is increased as a result of the arteriovenous shunt. Cardiac enlargement is not, as a rule, a complication, but may occur if the process is extensive. The characteristic findings of the arteriogram are those of dilatation of the arteries leading to the fistulae; absence of normal filling of the arteries distal to the fistulae; puddling of the medium in the region of the fistulae; and the appearance of the contrast medium in the veins distal to the point of injection in the first roentgenogram, when the proximal arteries are occluded.

The clinical findings and operative treatment of three patients with arteriovenous fistulae of the hand were described.

These cases pointed out the need for preoperative and postoperative arteriograms, as well as a need for planning and staging of the operative procedure. These are necessary in order that radical surgery can be carried out. Hand function can be preserved by the adequate collateral circulation which develops and by the use of skin and bone grafts where necessary. In these three patients there was no indication that surgical intervention caused the process to extend into areas where a normal vascular tree existed.

It is of utmost importance to recognize this clinical entity early and to institute a radical surgical program for excision of the arteriovenous communications before the process causes irreversible changes in the extremity, for in this manner it is possible to preserve hand function, yet to eradicate the process.

Dr. George V. Webster [32] emphasized the correlation between congenital arteriovenous fistula and hemangioma of the upper extremity. In most cases, these fistulae first appear as hemangiomata of the cavernous type. Other lesions occurring in middle life undoubtedly have their origin, as Dr. Curtis pointed out, in the common embryological capillary plexus, but they are undistinguishable from small cavernous hemangiomata.

Early recognition and treatment of cavernous hemangiomata will prevent some later arteriovenous channels from developing. In this connection, one should caution against the use of x-ray and radium therapy because of their effect on growth and epiphyses. Moreover, the atrophy of skin and subcutaneous structures following such treatment is at times crippling and disastrous. In one instance, an epithelioma was seen to have arisen in the irradiated scarred area on the arm in a female patient at twenty-three years of age following treatment of a cavernous hemangioma in infancy.

In conclusion, Dr. Webster called attention to the point, that, where arteriovenous communications extend within the marrow cavity of the long bones, whether in finger, forearm, or humerus, amputation of the affected long bone is the only curative treatment.

Dr. Thomas W. Stevenson [33] said that a good plan of attack had been outlined by Dr. Curtis. The arteriograms which he showed were beautifully executed. This should be an example for our future diagnostic procedures as well as a test of the efficacy of the excision.

Dr. Stevenson did not agree with Dr. Curtis's view that "it is possible to excise congenital arteriovenous

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fistulae"; he feels that a satisfactory outcome is not too probable. The blood pressure and flow rate are so high in the presence of multiple fistulae that satisfactory thrombosis cannot be obtained by sclerosing therapy. Indeed, this is the main cause for most of the technical difficulties and symptoms produced by this lesion, —namely, dilated veins leading from the lesion, sometimes pulsating, increased heat, chronic ulceration, hypertrophy, or enlargement of the part, bruit and thrill, active pulsation, and spontaneous or post-traumatic hemorrhage. Sometimes, the arteriovenous communications act as shunts so that there is absence of normal filling of the arteries distal to the fistula. This relative ischaemia often diminishes the growth of the part and occasionally predisposes to actual gangrene. In general it appears that a lesion with a single fistula is relatively easy to correct, but difficulty increases with multiplicity of communications and, if bone is involved, cure without amputation is practically unknown. He presented briefly three illustrative cases.

In closing, Dr. Curtis emphasized Dr. Webster's statement that arteriovenous fistulae can occur in cavernous hemangioma. He also wished to stress the role of trauma in this condition.

SATURDAY, JANUARY 24

Clinical Session, Northwestern University Medical School, Dr. Darrel T. Shaw, Presiding.

Three papers were presented:

Opposition of the Thumb by DR. EMANUEL B. KAPLAN[34].

This was a careful anatomical study based on the comparison of the anthropoid and human thumb. He discussed the question of opposition, the joints involved in the movement, and the muscles activating opposition.

Experiences in the Treatment of Leprosy. DR. PAUL BRAND[35].

Only in the last five years has surgery been used in leprosy; yet this disease accounts for more crippled hands than any other disease, probably for more than even industrial accidents. This lack of adequate treatment has been due to popular misconception of the disease. With slides and films he showed some of the interesting cases studied during his extensive experience in South India, as well as the methods of treatment which he had found most satisfactory.

Dupuytren's Contracture. DR. RAOUL TUBIANA[36].

This was a film presentation illustrating the author's method of treating this condition. The presentation aroused much interest and many questions from the audience.

DR. MICHAEL L. MASON [11] presided during the presentation of cases.

Dr. John L. Bell presented six patients who had been treated for various injuries of the hand. Many of these were due to industrial accidents.

Dr. Harvey Allen presented a series of young children in whom tendon grafts had been used to repair serious injuries to the tendons. These children have good function. He is convinced of the growth of the tendon graft in these cases.

Many members, interested in Dr. Allen's cases, cited their personal experiences in similar cases.

Dr. Michael L. Mason presented a series of slides illustrative of cases of x-ray dermatitis and squamous-cell carcinoma which had developed in irradiated areas, often many years after exposure. He warned against the use of radium or the x-ray therapeutically on the hand. It is never necessary, in view of other methods of treatment available.

At the business session of the Society the following officers were elected:

President-Elect: Joseph H. Boyes, M.D., Los Angeles, California
Vice-President: Julian M. Bruner, M.D., Des Moines, Iowa
Secretary-Treasurer: George V. Webster, M.D., Pasadena, California
Historian: S. Benjamin Fowler, M.D., Nashville, Tennessee
Member of the Council: William H. Frackelton, M.D., Milwaukee, Wisconsin

The President of the Society for the current year is Darrell T. Shaw, M.D., Cleveland, Ohio.

The following six surgeons were elected to membership:

Robert E. Carroll, M.D., New York, N. Y.
Don L. Eyler, M.D., Nashville, Tennessee
J. Leonard Goldner, M.D., Durham, North Carolina
C. E. Irwin, M.D., Warm Springs, Georgia
Michael L. Lewin, M.D., New York, N. Y.
Kenneth L. Pickrell, M.D., Durham, North Carolina

The next Annual Meeting will be held at the Palmer House, Chicago, on Friday, January 22, 1954.

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[35] Vellore, India.
[36] 47 Quai des Grands Augustins, Paris VI, France.

THE AMERICAN COLLEGE OF SURGEONS: THE FORUM ON FUNDAMENTAL SURGICAL PROBLEMS

Orthopaedic Section

At the Thirty-eighth Clinical Congress of the American College of Surgeons held in New York City on September 24, 1953, a program on Orthopaedic Surgery was presented at the Forum on Fundamental Surgical Problems. The following is a short report of these papers:

Study of Vascularization of Bone Transplants by Means of the Transparent Chamber and Microscopic Sections. Dr. Clifford L. Kiehn, Dr. Donald M. Glover, and Mr. James Gutentag [1] were able to study, by means of the transplant technique of Algire, the revascularization of autogenous and homogenous bone transplants. It was noted that blood vessels readily grew into the autogenous bone grafts, while the non-vital grafts were treated as foreign bodies and tended not to be vascularized but rather to be surrounded by young connective tissue.

Effect of Microwaves on the Healing of Experimentally Produced Fractures in Rabbits. Dr. Edward D. Henderson [2] produced subperiosteal fractures in both ulnae of rabbits. On one side the temperature was raised to 40 degrees centigrade (104 degrees Fahrenheit) without causing an increase in the rectal temperature. Twenty-three such rabbits were so treated for half-hour periods eleven times a week. The fracture on the other side served as a control. The rabbits were sacrificed at one, two, and three weeks. Gross and microscopic studies of the specimens showed no difference; it was concluded, therefore, that this degree of heat did not appreciably affect the quality or rapidity of healing of these factures.

Fanconi's Syndrome. Report of a Case Showing Response to Vitamin D. Dr. E. C. Froning, Dr. Genevieve Stearns, and Dr. M. Bonfiglio.[3] Fanconi's syndrome is tubular renal rickets with acidosis and renal glycosuria. In a patient presenting this syndrome with dwarfism, diffuse pigmentation of the skin, instability of the left knee, and dorsum rotundum, who was thirty years old and the mother of three children, and who had not walked for one year on account of muscle weakness, x-rays revealed severe bone atrophy and widespread pseudofractures with wedging, and concave compression of vertebral bodies. Calcium was normal and alkaline phosphatase was markedly elevated. There was polyuria with albuminuria and glycosuria and excessive amino acids. Vitamin D relieved the symptoms. The initial dose had been 20,000 units and this dosage was increased to a maintenance dose of 60,000 units daily. The patient became ambulatory, the fractures healed, and the negative calcium and nitrogen balances were corrected.

Early Surgical Biopsy of Vertebral-Body Lesions—A Diagnostic Necessity. Dr. R. W. Johnson, Jr., Dr. J. W. Hillman, and Dr. W. O. Southwick [4] stressed that with the increased availability and effectiveness of antibiotic agents and radio-active elements the exact diagnosis of destructive diseases of bone is more important than in the past. The authors presented a statistical review of a series of 400 cases in which the bodies and intervertebral discs of vertebrae were approached surgically and biopsy material was removed for diagnosis. They regard this method as one very much worth while.

Study of Stress in Relation to Healing of Bone. Dr. James A. Nicholas, Dr. Philip D. Wilson, and Dr. Charles Umberger [5] made a preliminary report on the effect of stress in orthopaedic patients which indicated that orthopaedic procedures affected the blood level of sodium, potassium, magnesium, calcium, phosphorus, amino acids and other proteins, as well as the eosinophil content of the peripheral blood. The results were correlated with clinical observations.

Bone Changes following Ureterosigmoidostomy. Dr. Mary S. Sherman [6] stated that even when kidney function is relatively normal, any patient who has had a bilateral ureterosigmoidostomy suffers alteration in his electrolyte balance and that selective resorption of chloride results in a variable degree of acidosis. Normally this is reversible and can be controlled by the oral administration of bicarbonate. If this is not done, the body's reserves are called upon and frank osteomalacia can result. This is a report of a study based upon clinical material.

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[3] State University of Iowa College of Medicine, Iowa City, Iowa
[4] Johns Hopkins Hospital, Baltimore, Maryland
[5] Columbia University College of Physicians and Surgeons, New York, N. Y.
[6] Division of Orthopaedic Surgery, Department of Surgery, University of Chicago School of Medicine, Chicago, Illinois

Mechanism and Clinical Correction of the Trendelenburg Gait. Dr. Charles O. Bechtol [7] stated that in normal walking there is a lateral displacement of the torso away from the weight-bearing hip. In the Trendelenburg gait, this shift is reversed in order to bring the center of gravity over the weight-bearing hip. In one-legged crutch walking, lateral displacement of the torso is eliminated and the foot contacts the ground directly under the center of gravity. The correction of the Trendelenburg limp is accomplished by holding the torso and pelvis rigid by the spinal muscles and exaggerating the normal shift away from the weight-bearing hip. This reduces strain on the spine and improves the appearance of the gait.

Aspiration Biopsy of the Spine. Dr. Charles J. Frankel,[8] from an experience with forty cases, stated that aspiration biopsy of the spine is a fairly simple and moderately effective procedure and that it yields satisfactory results in approximately 50 per cent. of the patients. The position of the needle is checked with the x-ray. The method of aspiration was described in detail.

Effects of Compression on Healing of Fractures. Dr. J. M. McIntyre and Dr. James G. Shannon [9] described an internal metal splint, consisting of a slotted plate and springs, designed to exert about fifteen pounds of tension. This was used to keep the fragments in apposition after transverse section of the shaft of the femur in dogs. There was evidence of union as early as three weeks after operation with solid union as early as eight weeks. None of the control fractures which were fixed with slotted plates or standard plates for similar periods showed evidence of union.

Experimental Study of the Use of Gelfoam, with and without Calcium Salts, to Fill Defects in Bone. Dr. Fred C. Reynolds and Dr. Lee T. Ford.[10] Gelfoam of the standard type and a special experimental type which was more resistant to absorption were each impregnated with a suspension of calcium salts. Both the standard and the experimental types were used to obliterate cavities produced in the long bones of dogs. The results were compared with those obtained by letting similar cavities heal without gelfoam and with those obtained by use of the standard and experimental gelfoam without calcium salts. It was found that the experimental gelfoam had retarded slightly but had not prevented the healing of the defects of bone and that the calcium apparently had no effect on the process. The standard gelfoam, either with or without calcium, did not retard or hasten or appreciably affect the healing of bone cavities.

Histological Studies following Exposures of Bone to Ultrasound. Dr. L. F. Bender, Dr. Joseph M. Janes, and Dr. J. F. Herrick [11] exposed the femora of anaesthetized dogs to ultrasonic energy of 5 to 20 watts of total output for about two to ten minutes. The dogs were sacrificed at intervals of one hour to twenty weeks afterward. Histological studies revealed normal structure in most cortices, but frequently hemorrhage was found in the medulla. In some femora there were fat necrosis and osteogenesis in the medulla.

Tendon Transplantation through Artificially Created Tendon Sheaths. Dr. Joseph E. Milgram [12] accomplished preliminary construction of a sheath by the transplantation of a non-irritating rod into the tissues three weeks prior to the tendon transplantation. This was done subcutaneously by means of minimal stab-wound incisions. Then the rod was removed and the tendon was transplanted into the newly formed sheath. Clinical results have indicated that it is a highly successful method in the hands of the author.

Influence of Hyaluronidase on Experimental Bone Repair and Ectopic Bone Formation. Dr. J. J. Gartland and Dr. W. R. MacAusland, Jr.[13] Hyaluronidase is a spreading factor and has been shown to accentuate the spread of local anaesthesia in the treatment of sprains and fractures. The authors have used it for the purpose of dispersing oedema and hematoma after operative and accidental injuries. They have also used it experimentally in an effort to determine whether or not it affects bone repair. In their experiments upon rabbits they found that, in the usual clinical donors, hyaluronidase has no influence on bone repair or on the repair of experimental fractures, except that, if the administration is prolonged, the processes may be slowed.

Metals and Plastics in Orthopaedic Surgery and General Surgery. Dr. J. W. Blunt, Jr., Dr. Stephen S. Hudack, and Dr. Clay Ray Murray [14] presented an extensive study of the reactions occurring around foreign bodies in the tissues. It included tantalum, SMo steel, 18-8 chrome-nickel-steel, Vitallium, and

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[13] Presbyterian Hospital, Columbia-Presbyterian Medical Center, New York Orthopaedic Hospital, New York, N. Y.
[14] Presbyterian Hospital, Columbia-Presbyterian Medical Center, New York, N. Y.

plastics. The plastics which absorb no moisture are the most inert and cause less reaction than silk or cotton. Reactions in the metals occur when two metals come into contact and are explained by the breaking and healing of the oxide coats caused by the slight movement of metal on metal. It is suggested that the blind use of plastics is dangerous as some of them are irritating or may even cause necrosis or be carcinogenic, while others of similar names are inert in the tissues. The College of Surgeons should establish some means of protecting surgeons against the misuse of such foreign materials. The plastics suitable for use as prostheses should be standardized.

Arterial Supply of the Muscles of the Lower Extremity. Anatomical and Clinical Study. Dr. Edward A. Edwards [16] read a carefully detailed study of the arterial supply of the important muscles of the lower extremity. The arterial supply was correlated with the occurrence of muscle ischaemia caused by occlusion of various branches of the main arterial trunk, especially by arterial sclerosis which may cause chronic ischaemia.

AMERICAN ACADEMY FOR CEREBRAL PALSY

The following are brief summaries of the papers presented at the Scientific Sessions of the Annual Meeting of the Academy held at the Cerebral Palsy Hospital at Duke University, Durham, North Carolina, October 2 to 4, 1952.

Social Service in Cerebral Palsy. Euzelia C. Smart [1] felt that it has become increasingly apparent to doctors and their various professional colleagues that too often it is not lack of good medical care but unresolved social problems that are the deterrents in rehabilitation of the child with cerebral palsy. If the total medical goal is to be obtained, medical treatment and social treatment must proceed together. The paper outlined the social problems involved in cerebral palsy for the parents, the child, and the community; it also outlined a few of the ways found helpful in meeting those problems. Psychological factors in cerebral palsy were emphasized. It was stated that the value of long and expensive programs in in-patient centers can be enhanced and justified by working with the family of the patient before the patient is returned to his home environment.

Patellar Advancement in Cerebral Palsy. Dr. John Adams [2] demonstrated and discussed the indications and technique of patellar advancement for the correction of the bent-knee walking of the patient with cerebral palsy.

Functional Anatomy of the Hand. Dr. J. E. Markee [3] showed a moving picture demonstrating the functional anatomy of the hand. The technique consisted of a dissection of the hand with the tendons separated and connected to manually operated leads. In this manner the individual function of each muscle, as well as the muscles acting in combination, was demonstrated.

Surgery of the Hand in Cerebral Palsy. Dr. J. Leonard Goldner [4] reviewed various surgical procedures useful in rehabilitation of the hand in cerebral palsy.

The Cerebral Palsy Problem in 1952. Dr. Leslie B. Hohman [5] reported a study of the intellectual status of children with cerebral palsy. Contrary to the previously published statements that two thirds of all children with cerebral palsy had intelligence comparable to the normal ranges, this study revealed that approximately 50 per cent. of all patients with cerebral palsy were feeble-minded. The remaining 50 per cent. were below average in intelligence, although they were considered as capable of education.

Clinical Approach to the Etiology of One Hundred Cases of Cerebral Palsy and Its Correlation with Signs and Symptoms. Dr. Leon Greenspan and Dr. George G. Deaver [6] correlated the etiological factors with the clinical signs and symptoms in 100 cases of cerebral palsy, the histories being obtained from parents, hospitals, and obstetricians.

Ninety-four of these cases were congenital cerebral palsy; six were acquired. The distribution of the cases according to type was no different from that described in the literature. There was an even distribution between males and females. Thus, from this study it was felt that the age of the mother was not a predisposing factor. Approximately 57 per cent. of the children were first-born.

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[3] Professor of Anatomy, Duke University School of Medicine, Durham, North Carolina.

[4] Assistant Professor of Orthopaedics, Duke University School of Medicine, Durham, North Carolina.

[5] Department of Psychiatry, Duke University School of Medicine, Durham, North Carolina.

[6] Institute of Physical Medicine and Rehabilitation, New York University-Bellevue Medical Center, New York, N. Y.

Sixty-one of the 94 patients with congenital cerebral palsy showed signs of cerebral damage during the neonatal period. In only eight could the factor of maternal anoxia be considered the only probable etiological factor in the cause of the brain damage; in five, anoxia, caused by foetal placenta or neonatal pathological conditions, could be said to be the only etiological factor.

Factors which may cause foetal or neonatal cerebral hemorrhage, such as toxaemia, dystocia, caesarean section, and forceps, may have been the etiological factor in only nine cases of congenital cerebral palsy. Thirty-one children had been premature; prematurity is apparently one of the outstanding factors in the etiology of cerebral palsy. However, complications of pregnancy and of labor were present in all but three of these infants.

The Rh factor was involved in seven of the patients. Diabetes, infection in the mother, hemorrhagic disease of the newborn, and twin pregnancies were contributory factors.

In the entire study, the outstanding finding was the overlapping of the so-called causative factors in cerebral palsy in the greatest majority of our cases.

Aphasia in Children. Dr. Alfred A. Strauss [7] felt that in order to distinguish aphasia in children as a developmental defect from aphasia in adults as a defect acquired after full language development, it may be advisable to term aphasia in children "oligophasia".

The report dealt mainly with various scientific specialties which have to be applied in the analysis and understanding of language under-development and language deficiency:

1. The linguistic approach provides comparative material on the constancy of normal language structure, as well as the range of its variability. Patterns of modification, such as simplification, are available in all languages, as Sapir states, as the "inherent tendency to economy of expression". In the language-deficient organism, economy of expression becomes the fulfillment of a need. One could say, aphoristically, the child's language is the language of the human race, the adult speaks the language of his culture.

2. The approach of genetic psychology will assist in understanding the development of symbolic expression in thoughts and the dependency of such growth on the development of perception.

3. The study of normal children's language provides a basis for comparative evaluation of defective language patterns.

4. Psychophysiology of auditory perception in particular stresses the importance of considering psychological as well as physiological factors in the acquisition of receptive language.

The contribution of these various specialties to the analysis of language development should be toward a greater integration of knowledge and further understanding of the essential nature of language itself. It may then be possible to describe the varieties of deviations or oligophasia and prescribe effective treatment.

A Practical Method to Discern Eye Defects in Cerebral Palsy. George Guibor [8] presented a practical method for examining the child with cerebral palsy. In general, the technique consists of:

1. The examiner covers the left eye, having the occluder against the left side of the nose, exposing the right eye.

2. The patient should be face forward. The patient's face should not be rotated (sideways), but should be held forward.

3. The examiner points to the large E, and the patient holds his hand in the direction in which the E symbol points.

4. When the direction suggested by the patient is incorrect, the examiner points to a second or third symbol in the line of E's in which this failure is made.

5. The examiner records the line of symbols which the patient can see.

Hip Derangements Seen in Children with Cerebral Palsy. Dr. Margaret H. Jones in collaboration with Dr. Samuel S. Mathews and Dr. Sidney C. Sperling [9] presented a group of thirty-two patients with cerebral palsy who showed roentgenographic evidence of derangement of the hip. Eighteen showed migration of the femoral head, eight showed non-congenital dislocation, and six showed probable congenital dislocation. The majority of these occurred in patients with severe spastic quadriplegia. Rigidity, with or without athetosis, appeared to be the main neuromuscular handicap in a few. Several occurred in those in whom flaccidity predominated. No relation to age, sex, or weight-bearing could be shown, except in the younger age group in which the abnormality found resembled congenital dislocation of the hip.

On a selected group of the thirty-two patients, adductor tenotomy and obturator neurectomy was carried out in an effort to prevent further migration of the femoral head.

Although the mechanism is obscure and the optimum therapy not yet defined, it was stressed that those who undertake the treatment of cerebral palsy must be aware of the possibility of subluxation or dislocation of the hips and that periodic roentgenograms of the pelvis must be made. In patients whose roentgenograms show a valgus of the neck of more than 150 degrees, one may anticipate early dislocation of the hip.

[7] Cove Schools for Brain-Injured Children, Racine, Wisconsin, and Evanston, Illinois.
[8] Ophthalmologist, St. Luke's Hospital, Chicago, Illinois.
[9] Children's Hospital Cerebral Palsy Clinic, Los Angeles, California.

Effect of Carbon Dioxide (20 per cent.) and Oxygen (80 per cent.) Inhalation on Movement and Muscular Hypertonus in Athetoids. Dr. Temple Fay [10] showed a moving picture demonstrating the effects of the inhalation of carbon dioxide and oxygen on the tension and extraneous motions of the severely involved athetoid patient. Prolonged improvement was demonstrated in the general condition of such patients, with relaxation, improvement in coordination for hand function and speech, and improvement in trunk-muscle control.

Observations on Fatigue Pattern of Anterior Tibial Muscles. Dr. J. E. Markee [3] stressed that the degree of tension exerted by the tibialis anterior appears to play a more important role in the development of fatigue than does muscle length.

Fatigue regression of the tibialis anterior may be due to tension exerted within the muscle by unequal involvement of the separate areas.

Closer scrutiny of the postpoliomyelitic patient with anterior tibial involvement should provide enough clinical data to enable the physician to recognize those who will undergo fatigue regression and take proper measures to avoid it.

Findings in paralyzed and paretic muscles indicated the advisability of determining whether segmental spasticity occurs in complex muscles.

Regional Pathology in Cerebral-Palsy Brains. Dr. H. W. Magoun [11] stated that he had been privileged during the past year to take part in the activities of the Brain Registry Program—somewhat in the capacity of a western branch. Through the generous cooperation of Dr. Meyer Perlstein nationally and of Dr. Margaret Jones and Dr. Nathan Malamud in California, eight brains from patients with cerebral palsy had been obtained. The patients had had an extensive clinical history. A considerably larger amount of brain material had also been secured from patients in whom only the more general clinical features were known. Slides illustrating the various phases of the study of this material were presented.

A Review of Surgical Procedures in Cerebral Palsy. Dr. Lenox D. Baker [12] showed a large series of children with cerebral palsy, and demonstrated the results of surgical and other orthopaedic forms of therapy.

Psychological and Physical Evaluation of Patients with Cerebral Palsy Studied for Periods of Ten Years or More.

I. *Psychological Evaluation.* Dr. Edith Meyer [13] stated that the use of the intelligence quotient has limited merit in cerebral palsy. Nevertheless predictions which were made on the group of patients studied were in general borne out by long periods of observation. In many cases it was the environment of the child that molded personality more than his own capabilities and deficiencies. Emphasis was placed upon the child's social handicaps. The study indicated that one should start treatment preferably during the nursery-school period and appraise difficulties realistically, setting goals which are attainable, giving early attention to the parental attitudes, stressing the development of social situations which will avoid competition, and spending more time in developing the patient's assets rather than attempting to overcome his difficulties.

II. *Physical Evaluation.* Dr. Bronson Crothers [14] reported that long-range study of children with cerebral palsy indicates that although original findings and prognostications are borne out by time, not infrequently children who have on first examination only signs of pyramidal-tract involvement may, after many years, develop signs of extrapyramidal involvement also. It was pointed out that the sensory disturbance in cerebral palsy may be an extremely important factor in judging the degree of disability.

Organization and Function of Day School Units for Cerebral Palsy. Dr. Samuel M. Wishik [15] and Dr. Zelda Klapper [16] stated that the cerebral-palsy day class is probably the most important single resource for the child with cerebral palsy of school age because of his need for frequent therapy and the more rapid improvement which ensues from the interweaving of educational and medical training. The result is a cerebral-palsy day-school unit of considerable complexity in facilities and personnel. This would be prohibitively expensive if the full array of therapy were offered to all cerebral palsied children throughout their school years and were utilized exclusively for those children. To bring the problem down to more obtainable dimensions, the paper raised and attempted to answer the most pressing questions.

[10] Philadelphia, Pennsylvania.
[11] Department of Anatomy, School of Medicine, University of California at Los Angeles, Los Angeles, California.
[12] Department of Orthopaedic Surgery, Duke University School of Medicine, Durham, North Carolina.
[13] Children's Hospital, Boston, Massachusetts.
[14] Children's Hospital, Boston, Massachusetts.
[15] Professor of Maternal and Child Health, Graduate School of Public Health, University of Pittsburgh, Pittsburgh, Pennsylvania.
[16] Department of Psychiatry, College of Medicine, State University of New York, Brooklyn, New York.

News Notes

THE AMERICAN ORTHOPAEDIC ASSOCIATION

The Sixty-sixth Annual Meeting of The American Orthopaedic Association will be held in Hot Springs, Virginia, June 29 to July 2, 1953, under the presidency of Dr. James A. Dickson. Prof. Bryan McFarland, of Liverpool, will be the guest of The Association at this meeting. A full and interesting program is offered and ample opportunity will be given for recreation.

The following program has been arranged:

MONDAY, JUNE 29

10:30 A.M.: Executive Session

Afternoon Session

Lateral Approaches to the Knee by Releasing the Lateral Ligaments from the Femoral Condyles.
O. E. Aufranc, M.D., Boston, Massachusetts.

Stapling of the Vertebral Bodies in the Treatment of Scoliosis.
A. DeF. Smith, M.D., New York, N. Y.;
W. H. von Lackum, M.D., New York, N. Y. (by invitation);
R. Wylie, M.D., New York, N. Y. (by invitation).

A Comparative Clinical Study of Autogenous and Frozen Homogenous Bone in Grafting Procedures.
E. A. Brav, M.D., San Francisco, California (by invitation).

The Use of Intramedullary Fixation and Cancellous Grafts in Established Non-Union of the Femoral Shaft.
H. D. Morris, M.D., New Orleans, Louisiana.

Fracture Healing after Fixation with Standard Plate, Contact Splints, and Medullary Nails.
F. C. Reynolds, M.D., St. Louis, Missouri;
J. A. Key, M.D., St. Louis, Missouri.

TUESDAY, JUNE 30

Morning Session

Developmental Deformities of the Lower Extremities.
R. A. Knight, M.D., Memphis, Tennessee.

Torsion of the Legs.
J. H. Kite, M.D., Atlanta, Georgia.

Spastic Flat-Foot due to Talocalcaneal Bridge.
R. I. Harris, M.D., Toronto, Ontario, Canada.

The Correlation of Congenital Dorsiflexion of the Ankle with Developmental Deformities of the Foot.
C. F. Ferciot, M.D., Lincoln, Nebraska.

Tuberculosis of the Spine; An End-Result Study of the Effects of the Spine-Fusion Operation in a Large Number of Patients.
H. Hallock, M.D., New York, N. Y.;
J. B. Jones, M.D., New York, N. Y. (by invitation).

The Surgical Management of Tuberculosis of the Hip.
F. P. Dewar, M.D., Toronto, Ontario, Canada (by invitation).

Epiphyseal Fusion for Early Slipping of the Upper Femoral Epiphysis.
C. H. Heyman, M.D., Cleveland, Ohio.

Noon

President's Address.
James A. Dickson, M.D., Cleveland, Ohio.

WEDNESDAY, JULY 1

Morning Session

Fractures of the Neck of the Femur in Dogs.
E. B. Tovee, M.D., Toronto, Ontario, Canada (by invitation).

Circulatory Status of the Femoral Head in Intracapsular Fractures of the Neck of the Femur.
F. E. West, M.D., San Diego, California;
R. M. Kimball, M.D., San Diego, California (by invitation);
R. E. Austin, M.D., San Diego, California (by invitation).

Results of Hip Arthroplasty with Inert Interposition.
Prof. R. M. d'Aubigné, Paris, France.

Experiences with the Use of a Vitallium Intramedullary Type of Hip Prosthesis.
F. R. Thompson, M.D., New York, N. Y.
The Treatment of Osteo-Arthritis of the Hip by Means of the Prosthesis Type of Arthroplasty.
E. L. Compere, M.D., Chicago, Illinois.
My Present Attitude to Osteo-Arthritis of the Hip.
Prof. Bryan McFarland, Liverpool, England.

THURSDAY, JULY 2

Morning Session

An Experimental Study of the Effects of Cortisone on the Healing Process and Tensile Strength of Tendons.
R. N. Wrenn, M.D., Durham, North Carolina (by invitation);
J. L. Goldner, M.D., Durham, North Carolina (by invitation);
J. E. Markee, M.D., Durham, North Carolina (by invitation).
The Use of Hydrocortisone Acetate (Compound F) in the Treatment of Common Orthopaedic Conditions.
H. H. Young, M.D., Rochester, Minnesota;
L. E. Ward, M.D., Rochester, Minnesota (by invitation);
E. D. Henderson, M.D., Rochester, Minnesota (by invitation).
Sling Procedure Survey with Recommended Modified Technique to Eliminate Earlier Shortcomings.
R. J. Joplin, M.D., Boston, Massachusetts.
Comparison of Congenital Defects Caused in Developing Chickens by Certain Teratogenic Agents with Those Induced by Insulin.
P. K. Duraiswami, M.D., Delhi, India (by invitation).

10:45 A.M.: Final Executive Session.

The Annual Banquet and Ball will be held Wednesday evening, July 1.

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SECTION ON ORTHOPAEDIC SURGERY

NEW YORK, N. Y., JUNE 1 TO 5, 1953

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Edward L. Compere, M.D., Chicago, Illinois

TUESDAY, JUNE 2

9:00 A.M.

The Early Roentgenographic Signs of Perthes' Disease.
Tom Outland, M.D., Harrisburg, Pennsylvania.
Discussion: Charles W. Goff, M.D., Hartford, Connecticut;
M. Beckett Howorth, M.D., New York, N. Y.

Panastragalar Arthrodesis.
Walter S. Hunt, Jr., M.D., and Hugh A. Thompson, M.D., Raleigh, North Carolina.
Discussion: Robert L. Patterson, M.D., New York, N. Y.;
Robert J. Joplin, M.D., Boston, Massachusetts.

The Treatment of Infection after Insertion of an Intramedullary Nail.
J. Albert Key, M.D., Fred C. Reynolds, M.D., and James O. Lottes, M.D., St. Louis, Missouri.
Discussion: Dana M. Street, M.D., Memphis, Tennessee;
Hugh Smith, M.D., Memphis, Tennessee.

The Effects of Extensive Radiation on the Healing of Fresh Fractures.
August W. Spittler, M.D., Joseph W. Batch, M.D., and Ben A. Rutledge, M.D., Walter Reed Army Hospital, Washington, D. C.
Discussion: Edgar M. Bick, M.D., New York, N. Y.;
A. R. Shands, Jr., M.D., Wilmington, Delaware.

The Triceps Surae Syndrome in Cerebral Palsy.
Lenox D. Baker, M.D., Durham, North Carolina.
Discussion: Charles N. Pease, M.D., Chicago, Illinois;
Frederick L. Liebolt, M.D., New York, N. Y.
Dupuytren's Contracture of the Foot.
Herbert E. Pedersen, M.D., and A. Jackson Day, M.D., Dearborn, Michigan.
Discussion: Leo C. Schlesinger, M.D., New Orleans, Louisiana;
Emanuel B. Kaplan, M.D., New York, N. Y.

WEDNESDAY, JUNE 3

9:00 A.M.

Election of Officers.
Early Management of the Injured Hand.
William D. Godfrey, M.D., and William D. Dugan, M.D., Buffalo, New York.
Discussion: J. William Littler, M.D., New York, N. Y.;
George O. Eaton, M.D., Baltimore, Maryland.
Spondylolisthesis.
Paul C. Colonna, M.D., Philadelphia, Pennsylvania.
Discussion: Frederic C. Bost, M.D., San Francisco, California;
John R. Norcross, M.D., Chicago, Illinois.
Chairman's Address: Has a Solution for the "Unsolved Fracture" Been Found?
H. Relton McCarroll, M.D., St. Louis, Missouri.
Problems in Management of Fractures of the Shaft of the Tibia.
Milton S. Thompson, M.D., Fort Sam Houston, Texas.
Discussion: John S. Thiemeyer, Jr., M.D., Portsmouth, Virginia;
Frank E. Stinchfield, M.D., New York, N. Y.
Flake Fracture of the Astragalus.
Bruce J. Brewer, M.D., Milwaukee, Wisconsin.
Discussion: Nicholas Giannestras, M.D., Cincinnati, Ohio;
Walter P. Blount, M.D., Milwaukee, Wisconsin.

THURSDAY, JUNE 4

9:00 A.M.

Are Bone Sarcomas Curable? A Panel Discussion.
Moderator: Bradley E. Coley, M.D., New York, N. Y.
Panel Members: Howard Hatcher, M.D., Chicago, Illinois;
Murray M. Copeland, M.D., Washington, D. C.;
Laurence Joseph Ackerman, M.D., St. Louis, Missouri;
J. Vernon Luck, M.D., Los Angeles, California;
Norman L. Higinbotham, M.D., New York, N. Y.

SOCIEDAD LATINO-AMERICANA DE ORTOPEDIA Y TRAUMATOLOGÍA
SOCIEDADE BRASILEIRA DE ORTOPEDIA E TRAUMATOLOGIA

The Second Meeting of the Latin American Society of Orthopaedics and Traumatology, under the presidency of Professor José Luiz Bado, and the Tenth Meeting of the Brazilian Society of Orthopaedics and Traumatology, whose president is Dr. Oswaldo Pinheiro Campos, will be held jointly in Rio de Janeiro, July 19 to 26, 1953.

The Organizing Committee is composed of:

President: Dr. Oswaldo Pinheiro Campos
Vice-President: Dr. Orlando Pinto de Souza
General Coordinator: Dr. Luthero Vargas
General Secretaries: Dr. Ricardo Luiz Ferreira da Costa and Dr. Marino Lazzareschi
Treasurer: Dr. Leopoldo Figueiredo Junior
Technical Secretary: Dr. Jorge Beiral Sardinha.

The scientific program of the Latin American Society includes the following topics:

The problem of the functional and social rehabilitation of the disabled; its different aspects.
Present-day surgical treatment of bone and joint tuberculosis; indications, technique, and late results.

Intramedullary nailing in fractures of the long bones; indications, technique, and end results.

The scientific program of the Brazilian Society includes the following topics:

Fractures of the wrist, including the lower end of the radius and ulna and the carpal bones.

Spine fusion: technique, indications, and critical analysis.

There will be symposia on scoliosis, reticulo-endothelioma, fractures of the calcaneus, fractures of the upper extremity of the humerus, and arthroplasties with metal and acrylic prostheses.

Courses will be given on the following subjects: surgical treatment of the paralytic foot, treatment of fractures of the upper extremity in childhood, recurrent dislocation of the shoulder, treatment of the paralytic pelvis and knee, and endocrine and metabolic bone disturbances.

For further information contact the Secretary of the meeting, Praça Floriano 31, 3° andar, sala 303, Rio de Janeiro, Brazil, South America.

Immediately following the joint meeting of the Latin American and Brazilian Societies, there will be dedicated in São Paulo the new building of "Clínica Ortopédica e Traumatológica" of São Paulo University. Professor Godoy Moreira is Director of the Clinic.

A symposium on the Rehabilitation of Amputees was held in Rio de Janeiro, November 24 to 29, 1952, under the auspices of the **Brazilian College of Surgeons.** Professor Dagmar Chaves of Rio was Chairman. The following scientific program was presented:

Amputee Bill in Brazil: Professor Achilles de Araujo, Rio de Janeiro.

Amputation Levels: Professor Barros Lima, Recife.

Social Aspect of the Rehabilitation of the Amputee in Industry: F. Bucolini, Welfare Commission of São Paulo.

Repair Surgery of the Limbs: Dr. A. Duarte Cardoso, São Paulo.

Report with demonstration of prosthesis by amputees of Brazilian Expeditionary Force: Major Spinola, Rio de Janeiro.

Practical and theoretical demonstration of the suction socket: Colonel Yedo Blauth, Rio de Janeiro.

An **Inter-American Meeting of the American College of Surgeons** was held in São Paulo on February 12, 1953. The session on orthopaedics and traumatology was conducted under the chairmanship of Professor Godoy Moreira at the University Orthopaedic Hospital. In the morning an operating clinic was held, followed by ward rounds in the Hospital. In the afternoon there was a splendid symposium on poliomyelitis.

SOCIEDAD DE CIRUJANOS DE CHILE

The Fourth Congress of the Society of Surgeons of Chile, corresponding to the Twenty-fifth Chilean Congress of Surgery, united with the Fourth International Congress of Hydatidosis for a meeting which was held November 21 to 24, 1952, in Santiago, Chile.

Among the papers presented as part of the general surgical program were "Osseous Echinococcosis" by Dr. Velarde Pérez Fontana, of Montevideo, and "Arthrodesis of the Hip" by Dr. Carlos Urrutia U., of Santiago.

Charlotte Memorial Hospital, Charlotte, North Carolina, announces the inauguration of two residencies in Orthopaedic Surgery supported by **The Miller Orthopaedic Clinic,** Charlotte and Gastonia, North Carolina. These residencies are designed to include all essential basic training required for certification in this specialty. They are also tendered in cooperation with the orthopaedic teaching program of any affiliating university which may desire to take advantage of these. The residencies will include the teaching of adult and children's orthopaedic surgery and fractures in hospitals caring for both private and charity patients. For further information, address the Charlotte Memorial Hospital or The Miller Orthopaedic Clinic.

On April 1, Dr. Joseph E. Milgram became full-time Director of Orthopaedics at the Hospital for Joint Diseases of New York City, a recently established post created in order to coordinate and amplify the present extensive clinical and scientific orthopaedic facilities for graduate education and patient treatment.

The Seventeenth Annual Meeting of the **Western Orthopedic Association** will be held at Sun Valley, Idaho, October 5 to 8, 1953, under the presidency of Dr. John F. LeCocq. Orthopaedic surgeons other than members who desire to attend the meeting as guests should communicate with the Office of the Secretary, 1301 Spring Street, Seattle 4, Washington.

The Sixth Congress of the **International Society of Orthopaedic Surgery and Traumatology** will be held in Bern, Switzerland, from August 30 to September 3, 1954.

Officers of the Society are as follows: Honorary President, Louis Ombrédanne; President, Sir Harry Platt; Vice-Presidents, Ramon San Ricart and Etienne Sorrel; Treasurer, Charles Parisel.

The Congress will be held under the presidency of Prof. Etienne Sorrel, with Prof. R. Scherb as Honorary President.

All correspondence should be addressed to the Secretary-General of the Society, Dr. J. Delchef, 34 Rue Montoyer, Bruxelles, Belgium.

The tentative program includes such subjects as the treatment of scoliosis, physiology of sport, physiology of movement, chemical aspects of orthopaedic surgery, bone and joint tuberculosis, bone and joint pathology, and surgery of the hand. Visits to near-by hospitals, research centers, and other institutions have been scheduled, as well as excursions at the close of the Congress.

Arrangements for simultaneous translation (French-English, English-French) have been made through the Swiss branch of International Business Machines.

PLASTIC SURGERY AWARDS — 1953

The Foundation of the **American Society of Plastic and Reconstructive Surgery** announces the regulation of the Fourth Annual Scholarship Contest:

1. The contest is restricted to residents in training and plastic surgeons who have been in practice no longer than five years.
2. Two main prizes are offered, each consisting of a six-months' scholarship in plastic surgery with active assistantship and full maintenance in a number of selected leading services.
3. The subject matter of the essay must be the result of some original research either clinical or laboratory in plastic and reconstructive surgery and about 5,000 words in length.
4. Traveling expenses between the services in the United States will be allotted.
5. A Silver Plaque or Certificate of Honorable Mention is also offered for a winning essay in the Senior Classification to contestants active in practice of plastic and reconstructive surgery for more than five years.
6. Manuscripts will not be accepted by the Award Committee after August 1, 1953.

The winning essays will appear on the program of the Annual Meeting of the American Society of Plastic and Reconstructive Surgery to be held at Coronado, California, November 2 to 6, 1953.

For further information write to the Award Committee, in care of Jacques W. Maliniac, M.D., Chairman, 30 Central Park South, New York 19, N. Y.

Sociedad Nacional de Cirugia of Cuba has elected the following officers for 1953 to 1954:

President: Dr. Antonio Rodríguez Díaz
Vice-President: Dr. Julio Sanguily
Secretary: Dr. Hilario Anido Fraguío
Vice-Secretary: Dr. Raúl Cañizares
Treasurer: Dr. Francisco González Monteavaro
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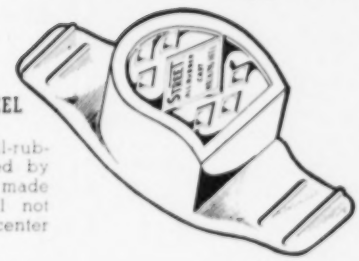

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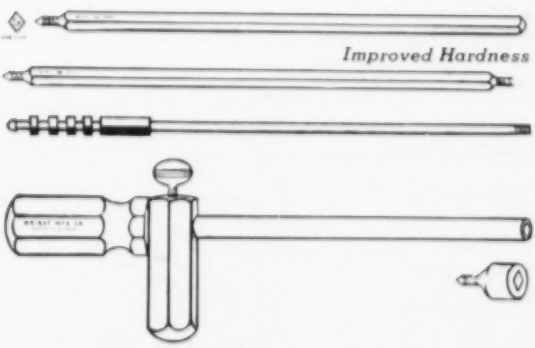

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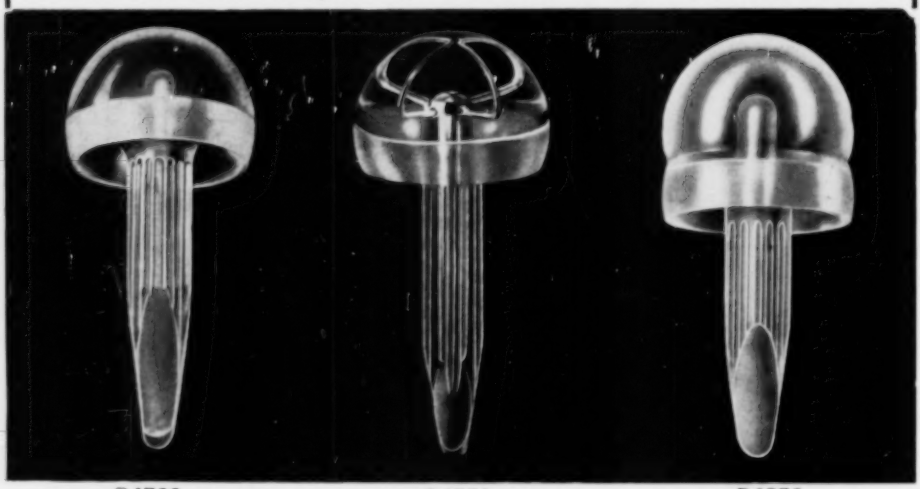

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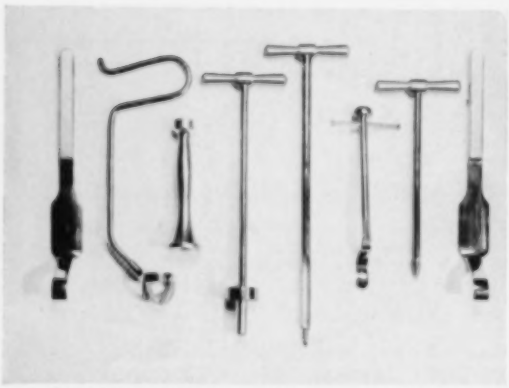

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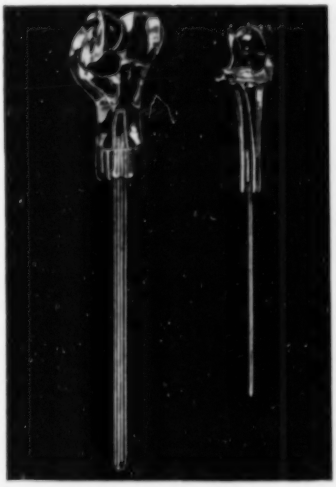

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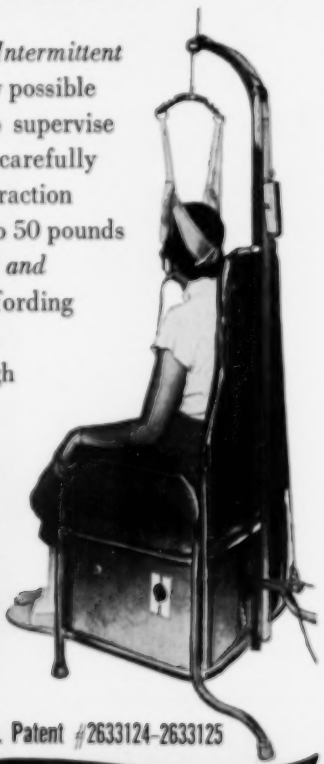

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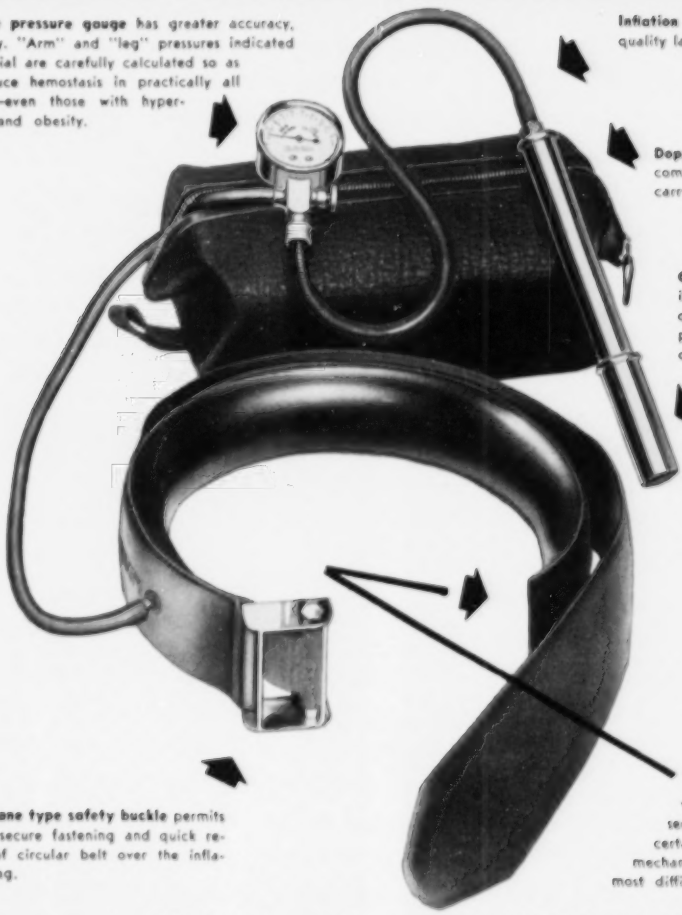

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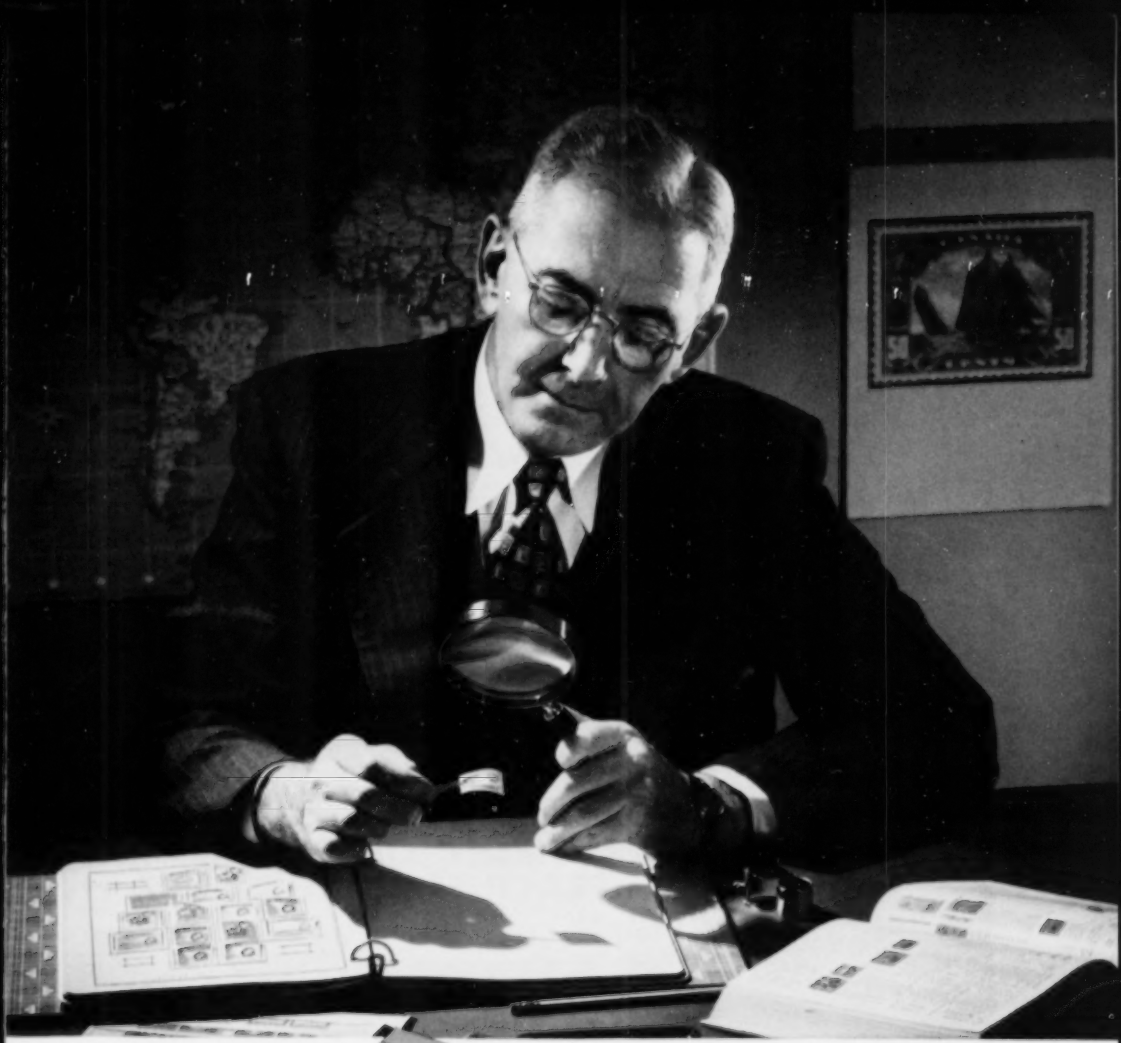

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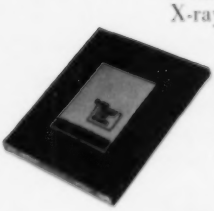

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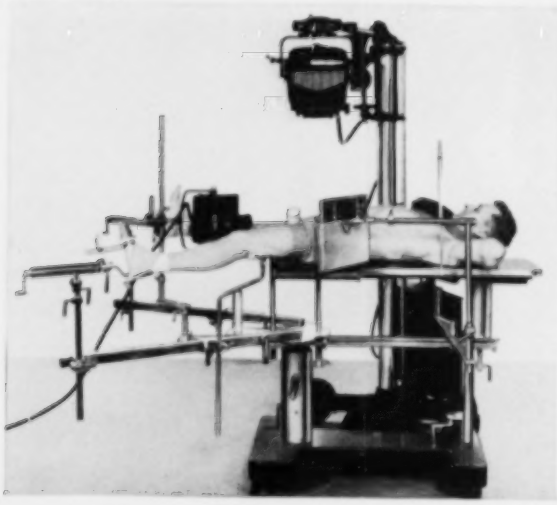

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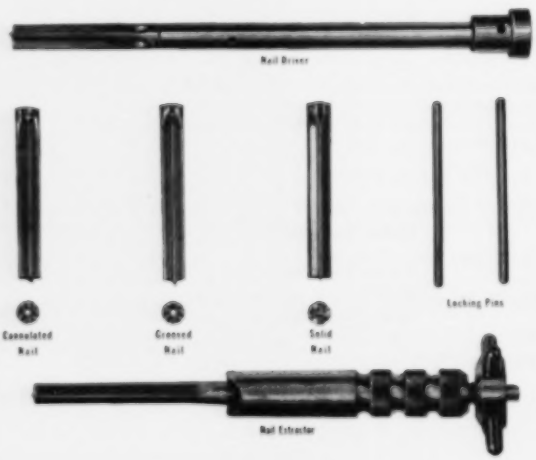

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FIG. 2

FIG. 1

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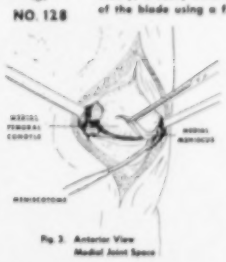

Fig. 3. Anterior View Medial Joint Space

FIG. 3

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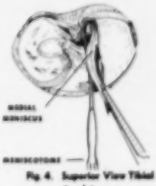

Fig. 4. Superior View Tibial Condyles

FIG. 4

If the surgeon favors the intercondylar approach to the posterior horn, the cartilage is freed until it can be dislocated into the notch. The Meniscotome is then slipped over the cartilage in the same manner, pushed back over the posterior horn which is then severed by drawing the knife towards the surgeon.

Fig. 5

FIG. 5

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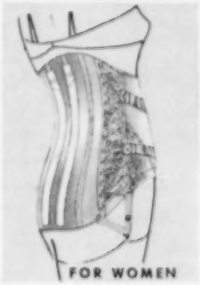

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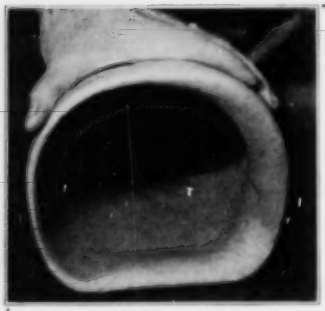

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